

SMALL ARMS

# DEFENSE

JOURNAL

VOL 14, NO 1 | JAN/FEB 2022

## PORTARMS

THE PORTUGUESE ARMY'S NEW BENELLI  
SUPER NOVA SHOTGUNS

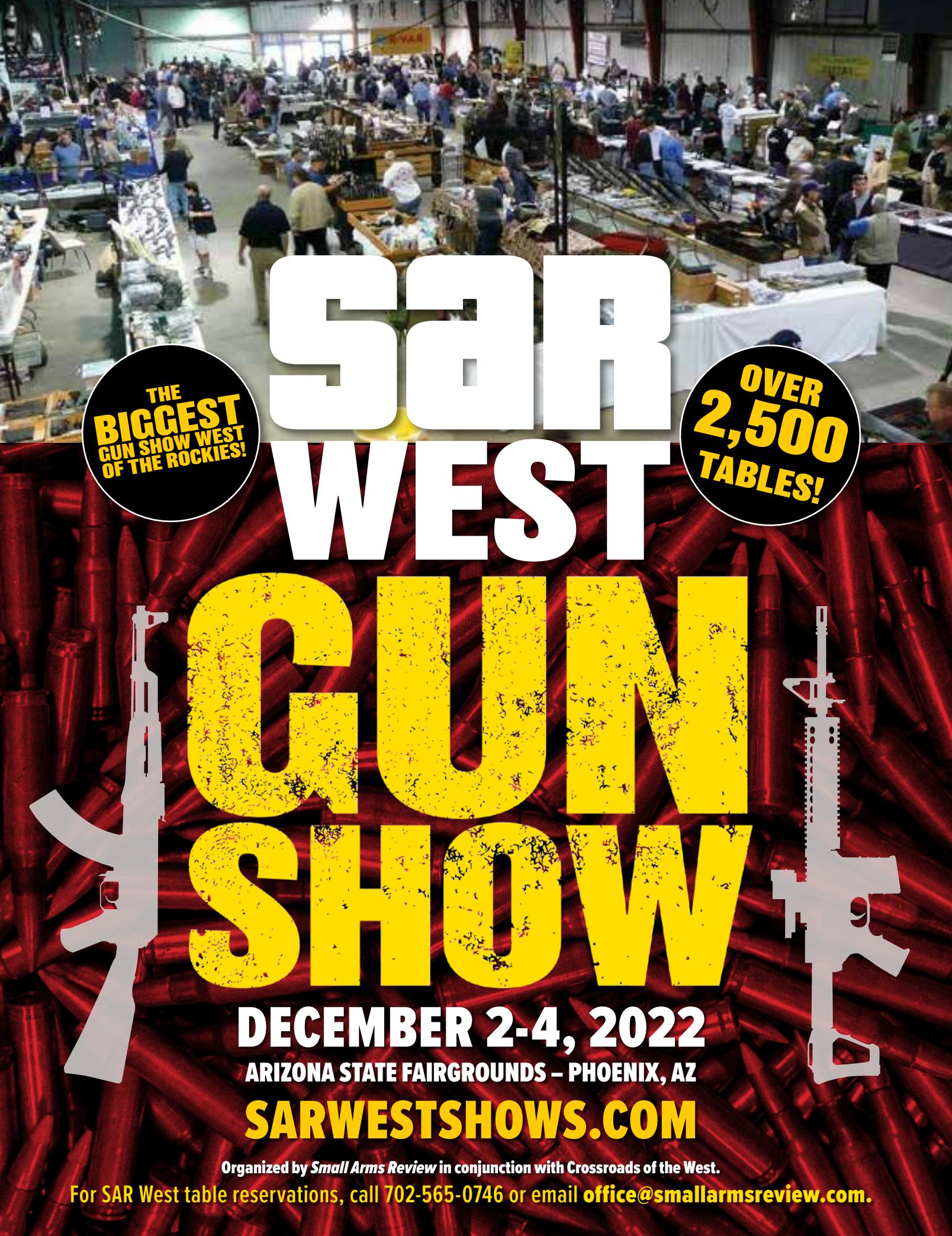
### TRB RS9 VAMPIR

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\* The French land and airland defence and security industries association

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# CONTENTS

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46

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## ON THE COVER

The Portuguese Army's new shotgun, the **Benelli Super Nova**, in use.

PHOTO: Bryan Ferreira

See Story on page 56

## FEATURES

- 12** CRIMSON TRACE-RAISING THE BAR FOR RED DOTS AND LIGHT/LASER PERFORMANCE ENHANCING GEAR  
TODD BURGREEN



- 24** SHOW REPORT: DEFENCE AND SECURITY EQUIPMENT INTERNATIONAL (DSEI) TRADE SHOW - 2021  
RICHARD JONES

- 34** WIND IN THE MOUNTAINS—UNDERSTANDING BALLISTIC EFFECTS  
WARD W. BRIEN

- 40** LONG RANGE GUNNERY FACTORS  
JEFF SIEWERT

- 46** TRB RS9 VAMPIR – BOSNIA'S FIRST SERVICE PISTOL  
PIERANGELO TENDAS

- 56** PORT ARMS – THE PORTUGUESE ARMY'S NEW BENELLI SUPER NOVA SHOTGUNS  
BRYAN FERREIRA

- 66** FEEDING THE BEAST – AN OVERVIEW OF GUN FEEDING SYSTEMS  
JEFF SIEWERT

## COLUMNS

- 8** NEW PRODUCTS

- 76** INDUSTRY NEWS

## CORRECTION & CLARIFICATION

In SADJ Vol. 13, No. 6, Building a Better Mousetrap, the M781 round is on the right side in the accompanying photos. SADJ regrets the error.



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# NEW PRODUCTS



## ISRAEL WEAPON INDUSTRIES

### ACE-N

The latest model in the Israel Weapon Industries' ACE family, the **ACE-N 52** has an improved ergonomic design that is suitable for use with standard NATO (AR-10) magazines, including 7.62x51mm ammunition.

Based on the mechanism of the famous GALIL assault rifle - which was the main assault rifle of the IDF - the ACE-N 52 is designed to enable forces to meet the challenges of the modern battlefield.

The ACE-N 52 meets the standards of MIL SDT 810, and IWI says it's able to withstand harsh weather and environ-

mental conditions. With a foldable AR butt and adjustable cheek rest, the new weapon enables flexible operation and enhances mission accuracy. This highly versatile weapon also features a Picatinny rail, to adapt a wide range of equipment.

"The ACE-N 52, with its enhanced ergonomic features, meets the needs of the modern battlefield," says Ronen Hamudot, Executive VP Marketing and Sales at SK Group and IWI, adding "an additional configuration of the ACE-N 52 has been adapted to the needs of the civilian market."

[iwi.net](http://iwi.net)



FOXFURY

## Nomad Transformer Scene Light

The **Nomad Transformer** is a powerful scene light that's ideal for incident command, relief centers, and large-scale SAR operations. The Transformer's silent operation helps communication in busy, chaotic situations. With built-in tripod legs, the Nomad Transformer extends up to 12.9 feet (3.9 meters) tall to deliver up to 17,600 lumens. This cordless, rechargeable LED light can operate as a spotlight, flood light or 360° scene light with a run time of up to 24 hours.

All Nomad scene lights share the perfect balance of compact portability and rugged performance for dealing with disaster response featuring fast deployment and easy break down allowing you to move when the conditions change, waterproof design, and rechargeable Li-ion battery packs that can be swapped out for continuous lighting.

[foxfury.com](http://foxfury.com)

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# NEW PRODUCTS

## FN HERSTAL

### **FN Herstal Smart ProtectoR**

FN Herstal, a major international actor in the field of kinetic energy less lethal capabilities with almost 25,000 FN 303 systems in service, presents a completely new concept; the **FN Smart ProtectoR**. The system is a credible alternative to systems such as rubber ball launchers and electroshock handguns for short and very short range engagements.

The FN Smart ProtectoR is an integrated, wearable and compact solution, which can be used safely in a proportional manner to deal with threats from individuals who are not using a firearm at short and very short ranges.

The FN Smart ProtectoR is composed of three complementary elements: the FN 306 launcher, the FN VictoR-SP image recognition system, and a red dot sight.

Fitted with a 5-tube magazine, the FN 306 launcher fires 12.55mm FN SP caliber cartridges featuring an elastomer projectile. This elastomer, specially designed for this level of force, has been made to drastically reduce the risk of bodily harm. Both the cartridge and the caliber are specific innovations from FN Herstal.

The incapacitation level of the FN 306 and its ammunition is equivalent to the effect generally given by a strike from a baton (30 joules) with a clear advantage for law enforcement and security forces; namely, being able to intervene from up to 10 meters, with extreme accuracy.

Unlike some less lethal systems on the market, there is no minimum safe distance for intervention with the FN



306. Handling of the launcher, which is compact and similar to a pistol, requires drills and procedures already acquired and mastered by police and security personnel.

Combined with the FN 306, the FN VictoR-SP is an innovative safety enhancing system that captures and analyses

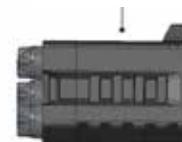
images in real-time to detect the shape of a human body and categorize specific parts of the body as areas that are authorized or forbidden to engage. If an area that must not be engaged, such as the head, is recognized, the system warns the user or prevents firing.

[fnherstal.com](http://fnherstal.com)

Round in chamber indicator



5-tube magazine



Elastomer projectile cartridge, 12.55FN SP calibre





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A CT RAD Max Pro was installed on the Radian Model 1 with a CT provided co-witnessing mount. The CT RAD Max Pro is a maximum sized open reflex sight specifically designed for carbines and shotguns.

# Crimson Trace

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Story & Photography By Todd Burgreen





The Crimson Trace CMR-301 Rail Master is multitasking at its best combining sighting laser and high intensity tactical light in one package. The CMR-301 allows a user to clean up the forward rail of a weapon.

## Raising the Bar for Red Dots and Light/ Laser Performance Enhancing Gear

**O**f late, much attention seems to be on improving both the AR and personal defense handgun platforms using a red dot optic, laser, and/or a high intensity light. This is not only for running more efficiently, but also more flexibility in responding to threats. Crimson Trace recently introduced multiple products to satisfy these needs. For the AR, Crimson Trace offers the CT RAD Max Pro (Rapid Aiming Dot) and CMR-301 Rail Master Pro light and laser combo. These two CT performance enhancers were mounted on a Radian Weapons Model 1 AR-style

rifle. The polymer striker fired handgun benchmark—the Glock 19—was used to proof the CT RAD Pro and CMR-207G light/laser combo.

We will start with the Crimson Trace-equipped Radian Model 1. The Radian AR-type rifle is a premium quality testbed enabling the CT RAD Max Pro and CMR-301 Rail Master Pro to fully demonstrate their capabilities. The Radian Model 1 uses the highest quality raw materials and build techniques—billet machined receivers, match 416R stainless barrel, polished crown and feed ramps, proprietary

M-Lok handguard, nitride coated bolt group, and more. Radian's own Raptor SD charging handle, Talon 45/90 safety selector, and Vertex trigger are incorporated, as well. The upper and lower receivers, along with hand guard, are Cerakoted together for a perfectly matched finish. The Model 1 features fully ambidextrous controls with a bonus—the Radian A-DAC (Ambidextrous Dual-Action Catch), which allows right-handed shooters to easily lock the bolt to the rear without taking their hand off the pistol grip. Every Model 1 is assembled by a trained gunsmith



Thanks to the oversized RAD Max Pro profile the manual brightness buttons are usable even with gloves on.

who builds one at a time, inspects, test fires, and cleans the weapon to personally guarantee it meets the most rigid quality standards.

#### CT's Big Red Dot Sight

A CT RAD Max Pro was installed on the Radian Model 1 with a CT-provided co-witnessing mount. The sight is a maximum-sized, open-reflex sight specifically designed for carbines and shotguns. Think of it as a supersized reflex sight. It features a recessed and fully multi-coated lens with an adjustable 3 MOA dot. CT has loaded the optic with enhancing technology such as an ambient light sensor that automatically adjusts the aiming dot's brightness for the surrounding lighting condition. A motion sensor detects movement of the firearm and automatically turns the reflex sight on. The sight powers off after two minutes



Training is the key to understanding how best to take advantage of what the Crimson Trace products offer. Here, the G19 equipped with RAD Pro and CMR-207G working at EVTC.

The Radian Model 1 AR with Crimson Trace red dot and light/laser performed well, especially during cover, movement, barricade, and unorthodox firing position drills.



without sensing movement. The CT RAD Max Pro comes with an auto-shut-off function that automatically shuts the sight off after eight consecutive hours of operation to conserve battery life, and a manual power function that

allows the user to turn the sight on or off using the side brightness buttons. CR2032 battery life is listed at 50,000 hours. Thanks to the oversized profile, the manual brightness buttons are usable even with gloves on. The RAD

Max Pro is further overbuilt thanks to CT choosing 7075 aerospace aluminum instead of the more typical 6061 aluminum. This makes the sight 30% stronger than most other open reflex sights on the market. Durability is fur-



ther enhanced with the RAD Max Pro's top having been designed to deflect impact forces if the sight's dropped or dragged across an obstruction.

#### CT's Light/Laser Combo

The second device mounted on the

rifle was CT's CMR-301 Rail Master Pro light and laser. The device was mounted forward on the Radian handguard. The flashlight provides 1000 lumens for illumination (the brightness can be adjusted down to

500 and 150 lumens) and a 5mW green laser for precision targeting in variable lighting conditions. The CMR-301 may be operated with pressure pad and/or tail-cap. It's ergonomically designed for quick activation and mode changes. The device's controls are very tactile and not prone to accidentally activate either laser or light inadvertently. Crimson Trace has designed the unit so the light and laser can be operated independently or together. It's powered with one rechargeable lithium battery. Battery life is listed as one hour of constant illumination.

The Crimson Trace CMR-301 is multi-tasking at its best, combining sighting laser and high intensity tactical light in one package. The CMR-301 allows a user to clean up the forward rail of a weapon. This modularity is important to maximize accessory rail space, as some weapons have minimal rail space due to short barrels or other design issues.

#### CT's Little Red Dot Sight

Switching gears to what Crimson Trace offers to enhance handgun performance. Proficiency with a handgun is one of the most perishable weapon skills. The solution arrived at was the same as most had already opted for with their rifles; add a red dot sight. A CT RAD Pro was added to a G19 MOS model. The RAD Pro matches up to a Docter RDS footprint for mounting purposes. The RAD Pro shares many of the same features listed for the RAD Max Pro; just in a smaller, more handgun-fitting size. It includes a motion sensor, auto shutoff, and even a robust 7075 aluminum construction. Runtime with a CR1632 battery is 20,000 hours. The RAD Pro can be used on rifle or shotgun thanks to the included picatinny mount. XS Sights R3D suppressor height sights were also installed on the host G19 – as it's always important to maintain co-witnessing iron sights with a red dot handgun intended for personal defense as a backup.

#### CT's Handgun Light

A Crimson Trace CMR-207G flashlight/laser was also mounted on the G19. The thought being, we might as well go all the way in evaluating Crimson Trace performance enhancing products. The light sports a compact, yet powerful, 400 lumen LED white light and 5 mW green aiming laser in one petite, durable unit. It features an aluminum body with ambidextrous activation points on either side. The user can choose operat-



Crimson Trace RAD Pro and CMR-207G mated to a G19.

ing modes, such as light only, laser only, or light and laser together. The unit will automatically power down after five minutes, thus preventing battery drain if activated inadvertently. The laser sight is adjustable for windage and elevation and is powered by a single CR123 battery. A C&G holster was chosen to accommodate the Crimson Trace MRDS/laser/light-equipped G19.

Civilians often blindly copy accessories found on military or law enforcement weapons without seriously considering benefits gained compared to the impact of the accessories on the weight and balance on the host firearm. This tacticool impulse is further reinforced if a weapon is not trained with properly, only being fired from a bench or from static positions. With that said, red dot sights as well as high intensity flashlights and lasers certainly have a role on rifles and handguns.



A C&G holster was chosen to accommodate Crimson Trace red dot/laser/light equipped G19.



The CMR-301 Rail Master Pro can be mounted at various positions on a rifle's handguard.

### Range Time

Training is the key to understanding how to take advantage of the performance gains Crimson Trace products offer. I decided to go all in and combine the Crimson Trace-equipped rifle and pistol together in multiple training scenarios. Fortunately, my home range, Echo Valley Training Center, offers the type of infrastructure to support this via large three-sided firing bays, "Jungle Walk" lanes, and Hesco CQB shoot house. The Radian rifle with Crimson Trace RAD Max Pro and CMR-301 Rail Master Pro balances performance with handling. The Radian AR with CT red dot and light/laser performed dynamically, especially during cover, movement, barricade, and unorthodox firing position drills. The G19 pistol with CT RAD Pro red dot and CMR-207G light/laser was mixed into transition drills with the rifle



The CMR-301 Rail Master Pro may be operated with pressure pad and/or tail-cap. The CT CMR-301 is ergonomically designed for quick activation and mode changes.



We went all-in by combining the Crimson Trace equipped Radian Model 1 and G19 to explore benefits offered by Crimson Trace red dots and light/lasers.

and was featured once we got to the Hesco shoot house. The rifle was not left out of the CQB drills, thanks to frangible ammunition making shooting steel at close range possible. The rifle equipped with CT devices made short work of striking targets in quick fashion. The Crimson Trace green lasers found with the CMR-301 and CMR-207G were easily

visible at CQB distances even during the day. Over 350 rounds were fired during our evaluation with both the Radian AR and G19. No reliability or function issues were encountered with weapons or the Crimson Trace products.

#### Using a Red Dot

Red dots are pretty much accepted

and standard equipment on rifles and becoming that way on handguns. The ability to place the G19 CT RAD Pro red dot on a target and not having to align front and rear irons proves much more efficient at moving rapidly between targets. This is achieved because the dot is superimposed as an aiming point on the target. A user can now do as



nature intends--focus on the target/threat. Shooting with both eyes open is strongly suggested; it is a must to get the most out of the red dot concept. Moreover, because the indexing of a red dot is far easier than two pieces of steel, shooters find they can perform beyond what was considered possible with iron sights. All simply because the

concept uses the eyes in a more normal manner. The CT RAD Max Pro and RAD Pro offer large field of view and an easy-to-locate red dot.

### Using a Laser

The T&E helped to revive previous experience and training with lasers. Rediscovered was the best practice of focusing on the target to pick up the

projected laser. This is like using a red dot; thus, red dot and laser use reinforce each other. One must train with a laser sight as seriously as one would with open sights. Resist the urge look at both the fixed sights and laser before firing the shot. The laser's advantage rests in the natural tendency to focus on the imminent threat versus



A Crimson Trace RAD Pro was added to a G19 MOS. The RAD Pro matches up to a Docter sight footprint for mounting purposes. XS Sights R3D suppressor height sights were also installed on the host G19.

at the front sight interposed between the threat and the shooter. The laser is seen on the target where the eye is naturally drawn. The key to success is to look at the target, pick up the flash of the laser, and squeeze off the round without referencing the fixed sights. Shooters must have confidence the bullet will indeed strike where the laser is aimed. This is achieved by practice. Training with iron sights puts so much emphasis on sight picture that it takes time getting used to finding the laser on the intended target without referencing the front sight.

The positives of the Crimson Trace laser sights are hard to deny. The shooter can get the weapon on target quickly, especially in low light, without having to spend an inordinate amount of time aligning sights—red dot or iron. Training and familiarizing yourself with your laser-equipped weapon will pay dividends in getting

smoother and faster with this process. Outside of defensive situations, lasers are useful training aids. They help the shooter to see how the gun is moving during target practice. They are useful for dry-fire exercise, as well, since you can see if you are slapping the trigger and pulling your shots.

Another benefit of laser use is not requiring a standard presentation of the weapon or a standard sight picture for effective use. Imagine crouching behind a car trunk with head below the bumper with rifle or handgun held at arm's length with Crimson Trace green laser on target allowing for engagement from such an untypical position. The CMR-301 Rail Master Pro and CMR-207G light/lasers literally keeps controls at your fingertips without having to change grip to activate either laser or light. Crimson Trace CMR-301 and CMR-207G enhances weapon capability

with their versatility, while minimizing any adverse impact on handling if light and laser components were separate entities.

All Crimson Trace devices featured in this article are intended for maximizing effectiveness during a fight or realistic training on the range. The CT RAD MAX Pro, CMR-301, RAD Pro, and CMR-207G are intended for serious practitioners who plan on using for patrolling, training, or defense. **SADJ**

## WEBSITES OF INTEREST

Crimson Trace Corporation  
[crimsontrace.com](http://crimsontrace.com)

Echo Valley Training Center  
[echovalleytraining.com](http://echovalleytraining.com)

Radian Weapons  
[radianfirearms.com](http://radianfirearms.com)

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# SHOW REPORT: DSEI

By Richard Jones



Rheinmetall BAE Systems Land (RBSL) Challenger 3 main battle tank

## Defence and Security Equipment International (DSEI) Trade Show - 2021

### Overview

The 2021 edition of DSEI was again held in its traditional venue of the Excel Centre, located in the London docklands. Held biennially, the last show took place in 2019 just as the cur-

rent global pandemic crisis was taking hold, subsequently causing many similar defense expos to cancel as the result of ongoing travel and meeting restrictions. The 2021 show was a marker on how the defense and secu-

rity exhibition industry in the European context, at least, was beginning to return to the previous level – DSEI being a major participant, alternating annually with Eurosatory, which was cancelled in 2020. Like many other



defense related shows, attendance at DSEI is limited to professional attendees only.

Overall, the number of visitors appeared to be slightly down from previous years, perhaps not unexpectedly, but a lifting of international visitor restrictions to the United Kingdom shortly before the event opened the event to the international community of exhibitors and visitors.

Traditionally DSEI has featured land forces systems and equipment,

with a maritime component of visiting naval vessels and light watercraft displays on the adjacent docking area forming part of the Excel Centre complex. Floor plan layout consists of major exhibitors or national pavilions around which are grouped national exhibitors, with smaller independent booths intermingled amongst the former.

### Highlights

Being UK-based, DSEI had a large British presence. Shown here on the outdoor display area is the BAE Sys-

tems **Archer** 155mm, 52 caliber barrel mobile howitzer system mounted on an 8 x 8 chassis. A standard Archer gun crew consists of only four members, control and firing is conducted from within the vehicle's armored cab, the first round is fired within 30 seconds of vehicle halting, firing precision guided munition (PGM) of the Excalibur type, a range of 60km is claimed. The complete system is transportable by heavy-lift aircraft such as the C17 or A400M Atlas.

At the other end of the scale and

# SHOW REPORT: DSEI



on display in the British Army display area was the **Integrated Digital Soldier** mannequin, successor to the decades-long soldier modernization program that began with the 'FIST' (Future Integrated Soldier Technology) program in the early 2000's. Shown in the lower part

of the image is the current L85A3 variant of the SA-80 assault rifle with the recently adopted ARILLS (Assault Rifle In-Line Low Light Sight) mounted forward of the daytime optical sight.

Also on display was the General Dynamics **Ajax** tracked reconnaiss-

sance vehicle, developed for the British Army. It has attracted attention as the result of media reported claims that the vehicle posed crew ergonomic and performance issues. Reportedly, a UK MoD resolution on the future of the Ajax development was due imminently at the



British Army  
Integrated  
Digital Soldier

tries and other enhancements. The upgraded Challenger 3, of which 148 have reportedly been ordered, is expected to remain in British service until, at least, 2040.

Hirtenberger Defence Systems, the well-known Austrian manufacturer of mortars up to 120mm caliber, displayed a range of their product line. In the left background is the 60mm **M6C-640 Mk1 Commando** mortar fitted with GRAM - (Grid Aiming Mode), a digital aiming device. In the right foreground is the 81 mm mortar fitted with the integrated display unit of the MDAS - (Mortar Digital Aiming System).

The French manufacturer CTA International showed their 40 mm Cased

Telescoped Armaments System (**40 CTAS**), which is already in service with the French Army mounted on the Jaguar wheeled/armored vehicle and intended for installation on the British AJAX tracked reconnaissance vehicle, should the latter go into service following a UK government decision not to upgrade the in-service Warrior IFV.

Another regular England-based exhibitor was MSI Defence Systems (MSI-DS) displaying a number of their medium-caliber mounting and fire-control systems. Its centerpiece is the company's **MSI-DS Seahawk** gun system offered in several calibers, 25mm through 40mm.

The **MSI-DS Seahawk Multi Weapon Station** (MWS) mounting as

time of the show.

Continuing the British theme, the Rheinmetall BAE Systems Land (RBSL) **Challenger 3** main battle tank was on display, fitted with a new 120mm smooth-bore gun (to replace the aging L30A1 rifled barrel ordnance) already in use with many NATO coun-

# SHOW REPORT: DSEI



General Dynamics Ajax tracked reconnaissance vehicle

fitted to the **BAE Systems Autonomous Pacific 24 MK IV** patrol craft. The latter provides an unmanned capability with automated navigational decision-making technologies for persistent anti-piracy border control use, as well as intelligence gathering capability. (For the keen observer, the mount is fitted with a mock-up copy of the 12.7mm/.50 Browning HMG.)

## Small Arms Corner

Several small arms manufacturers were at the show including FN Herstal with a major stand who displayed alongside their current product line their recently introduced **Evolys** ultra-light belt-fed machine guns, successors perhaps to the Minimi and Mk48 in 5.56mm NATO and 7.62mm NATO cal-



French manufacturer CTA International showed their 40 mm Cased-Telescoped Armaments System (40 CTAS).



60mm M6C-640 Mk1 Commando mortar



The MSI-DS Seahawk Multi-Weapon Station (MWS) mounting as fitted to the BAE Systems Autonomous Pacific 24 MK IV patrol craft.

ibers, respectively.

The 5.56 x 45 mm NATO caliber **Evolys** weighs in at around 5.5 kg (12.12 pounds) with a max overall length of 1,025mm (37.40 inches) with a 355mm (14-inch) barrel. Unlike the Minimi, the 5.56mm version doesn't offer an alternative box magazine feed system.

The 7.62 x 51 mm NATO caliber **Evolys** weighs in at 6.2 kg (13.66 pounds) with a max overall length of 1,025mm (40.35 inches) with a 406mm (16-inch) barrel.

The Polska Grupa Zbrojeniowa (Polish Armament Group) or 'PGZ' displayed a range of products by FB "Łucznik" Radom that included examples of the recently introduced

Polish armed forces services **GROT Arrowhead** 5.56 mm NATO modular assault rifle, **UK2000P** 7.62mm NATO general purpose-machine gun, and the recently introduced FB Radom **GROT** semi-automatic sniper rifle.

Located in the Austrian Pavilion was the Steyr booth with a range of the company's current product line,



A full range of ammunition types now have been developed for the 40 CTAS. Left to Right: APFSDS-T; KE Airburst; GP Airburst-Tracer; GP Point Detonating-Tracer; GP KE-Tracer; TP-Tracer and TP Reduced Range-Tracer, with conventional 30 mm bottle-necked case cartridge shown for comparison purposes.

# SHOW REPORT: DSEI



The 7.62 x 51 mm NATO caliber Evolys weighs in at 6.2 kg (13.66 pounds) with a max overall length of 1,025mm (40.35 inches) with a 406mm (16-inch) barrel.

including the now venerable Steyr AUG which continues to be the principal assault rifle of the Austrian armed forces. Shown below is the **Steyr HS50-M1** 12.7mm/.50 Browning caliber anti-material rifle.

ST Engineering of Singapore displayed a range of their current small arms. Shown here are the (clockwise from top-left) 40GL Mk1 40x46mm low-velocity, under-barrel (or stand-alone) grenade launcher, CPW (Compact Personal Weapon), SAR21 5.56mm NATO caliber assault rifle with revised handguard, Ultimax 100 Mk8 5.56mm NATO light machine gun.

Beretta Defense Technologies (BDT) exhibited a full range of their product line and also of their associated companies.

Barrett Firearms was recently awarded a multi-million dollar contract for its MRAD (Multi-Role Adaptive Design) sniper rifle, by the U.S. Army as the MK22 MOD 0, which reportedly will replace several other platforms currently in the U.S. military inventory.

Accuracy International Ltd, another UK-based manufacturer of military sniping and commercial target rifles, presented their latest AX MKIII



The Polska Grupa Zbrojeniowa (Polish Armament Group) UK2000P 7.62mm NATO general purpose-machine gun.



Polish armed forces services GROT Arrowhead 5.56 mm NATO modular assault rifle.



Steyr HS50-M1 12,7mm/.50 Browning caliber anti-material rifle



The Barrett booth.

multi-caliber rifle and **AX 50 ELR** anti-material rifle.

Edgar Brothers, the UK distributor for SIG-Sauer and Knights Armament Company were in attendance offering in addition an extended range of military and law-enforcement equipment and accessories.

Canada was represented by Colt Canada exhibiting under its new ownership of the CZ Group.

An unexpected exhibitor was Kalashnikov USA, offering a range of military and commercial copies of the historic AK-series rifles. All manufacturing is done at their U.S.-based facility and their product

Colt Canada exhibited under its new ownership of the CZ Group.



# SHOW REPORT: DSEI

Kalashnikov USA, offered a range of military and commercial copies of the historic AK-series rifles made in the USA.



line is not subject to 'import/export sanctions' faced by eastern European-made firearms, where these might be in place.

The Israeli manufacturer of missile systems Rafael showed their current line of anti-armor/anti-personnel missiles developed under the '**SPIKE**', **Precision Tactical Guided Missiles Family** banner. Now in the fifth-generation of development, international users have exceeded more than thirty in number.

Optics and night-vision equipment have seen major advancements in recent years, yet the number of exhibitors in this area seemed down compared to previous years. Those who were in attendance included **Opticolectron**, the Bulgarian manufacturer of a range of sighting devices including advanced day and night sighting systems for the generic RPG-7 series of grenade-launchers, whose capability has received significant enhancement through innovative projectile development in recent years.

The Excelitas Technologies-Qioptiq group were the main UK-based exhibitor with a range of products displayed.



The Israeli manufacturer Rafael showed their current line of anti-armor/anti-personnel missiles developed under the '**SPIKE**', **Precision Tactical Guided Missiles Family** banner.



HMS Argyll, a Type 23 Frigate was the largest vessel on display at 4,000 tons with a length of 133 meters.

Qioptic has been a major supplier of optical equipment to the UK MoD for many years.

### Maritime Component

The Excel Centre is located in the area of old Royal Victory Dock with visiting naval vessels tying-up along the south side of the center. As well as displays of small riverine craft. Conducted tours (which must be pre-booked) of visiting naval vessels are also available. **HMS Argyll**, a Type 23 Frigate was the largest vessel at 4,000 tons with a length of 133 meters.

Overall impression of the show was that attendance by exhibitors and visitors was good and, notwithstanding current global pandemic issues, a return to the success of previous shows is a marker for future events of this type as the world gets back to the new normal.

Next show dates are posted as 12-15 September 2023. **SADJ**



The Bulgarian manufacturer Optoelectron, showed a range of sighting devices including advanced day and night sighting systems for the generic RPG-7 series of grenade-launchers.



RAUFOSS Round

# Wind in the Mountains

## Understanding , Negotiating, and Pre-Mission Planning

By Ward W. Brien

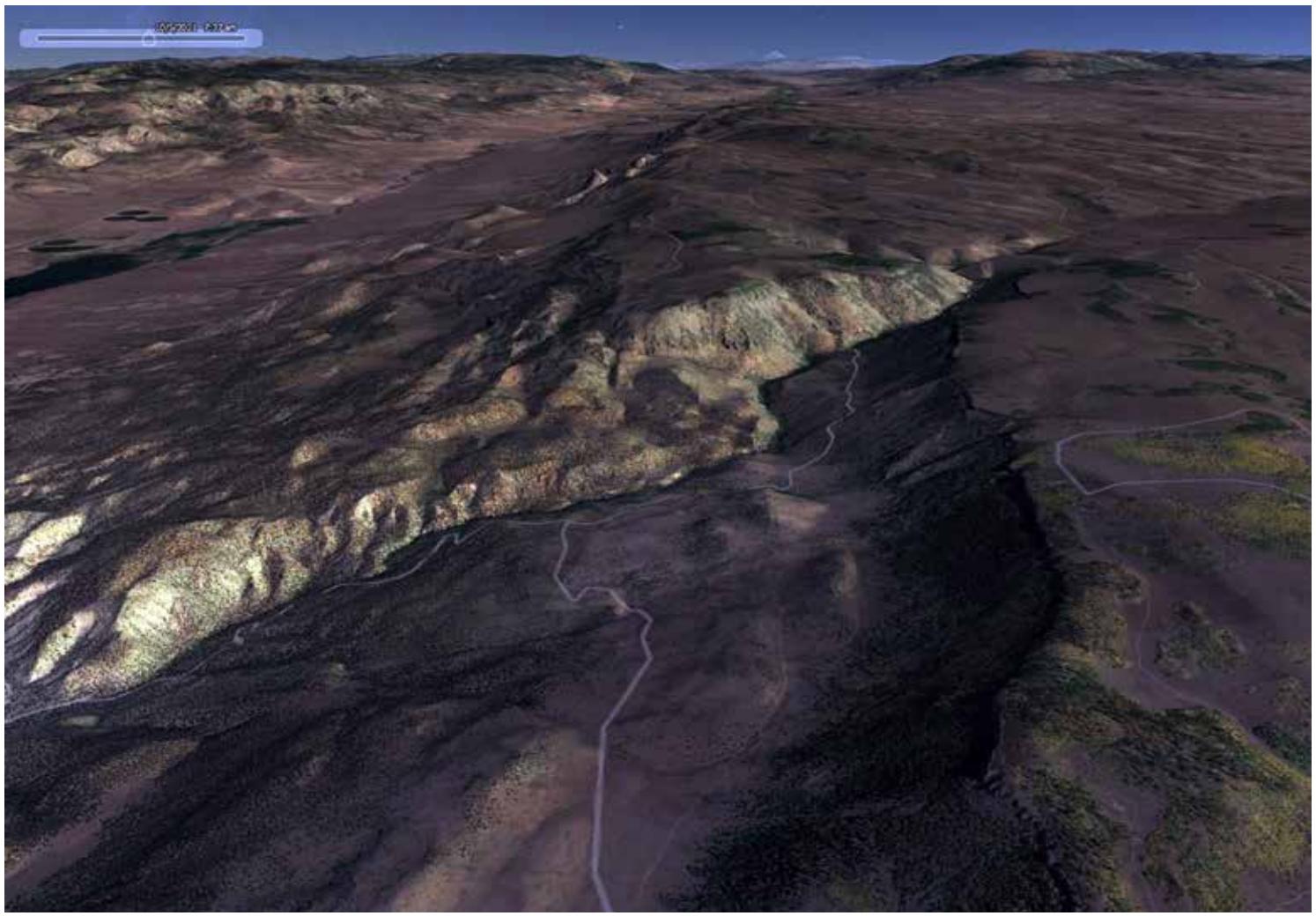
**A**bout two decades ago, Sgt. Maj. Michael LaBonte contacted me from his forward operating base in Afghanistan with two requests. First, could I send him a ballistic data card for the .50 caliber Raufoss Mk 211 Mod 0 round (the Raufoss is a multi-purpose anti-materiel high-explosive incendiary and armor-piercing projectile produced by Nammo). And, second, he asked for

information regarding the wind patterns of his area of operations.

I requested his meteorological (MET) data, barrel twist rate and velocity. So, while he was busy gathering that information, I contacted another friend of mine, who was working for Nammo Tally. Nammo was formed from the company Raufoss Ammunisjonsfabrikker which translates into, "Red Waterfall

Ammunition Factories" in Norwegian.

I obtained the ballistic coefficients, and pertinent bullet data needed to produce a data card from my friend at Nammo. Once generated, I emailed it to Labonte. However, the snipers, who were at times on missions in Margah Ada in the Bermal District, and also the eastern Paktika province, lacked formal mountain shooting training. The



Early morning heating of the terrain.

data card afforded them a piece of the puzzle, but they needed much more.

### What more could they need?

LaBonte requested information on wind, however, even though the wind is a significant element of the puzzle, it must first be understood and then negotiated. Wind patterns are caused either by high or low-pressure systems, such as an incoming front, or the heating and cooling of the terrain. In addition, Snell's Law of refraction must be considered along with other optical anomalies.

The Mountain Shooting Center (MSC) is a private training facility in southern Utah. It offers steep angle, high altitude, mountain shooting courses, which includes wind and optical anomaly segments within the curriculum. The courses run through the summer months for civilians and throughout the year for military and law enforcement snipers.

### Starting the class at the MSC

Reading wind is considered an art. However, it is merely picking it apart and developing a skill for knowing its

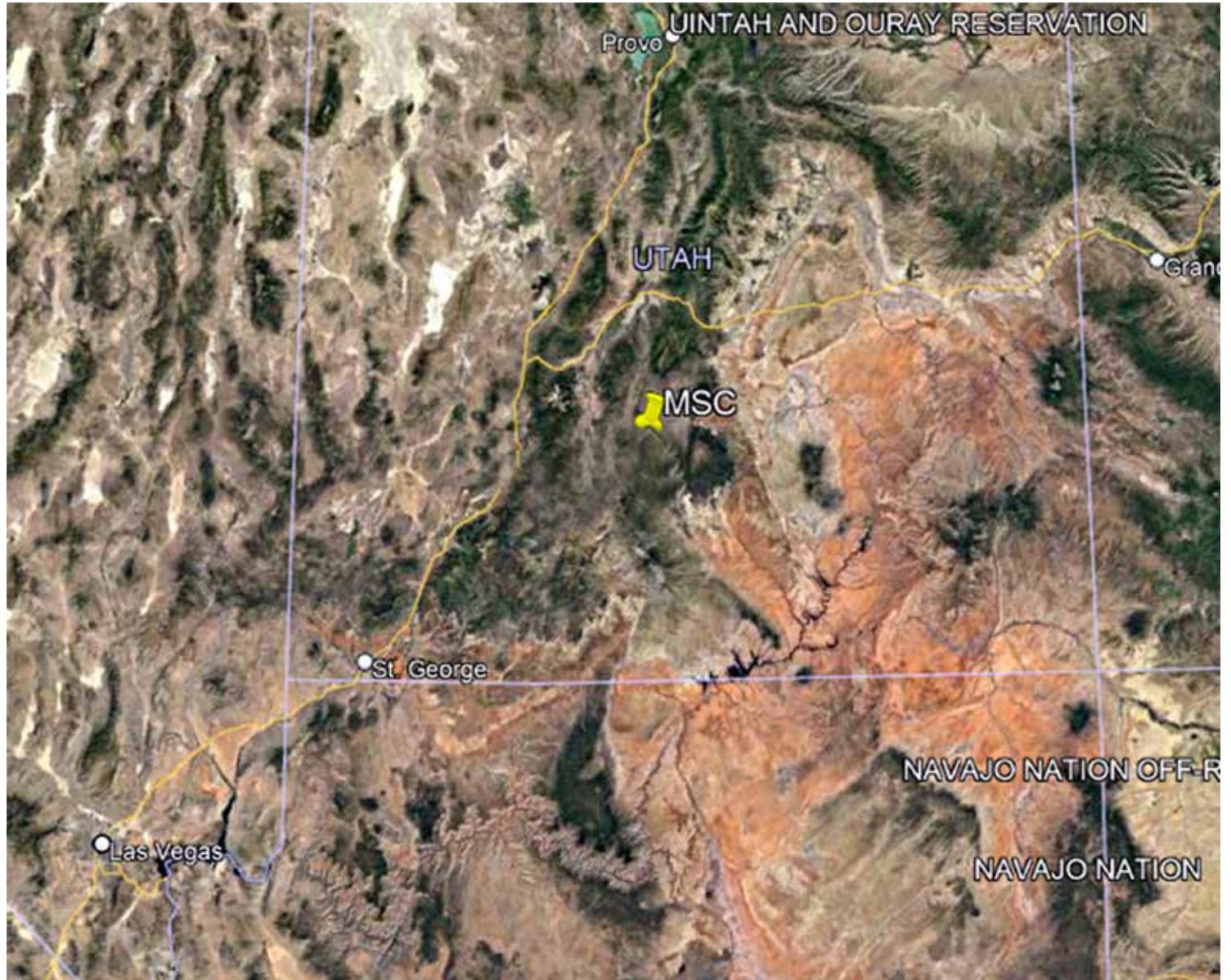
direction, speed and pattern throughout the day. In a high-altitude, mountainous environment during the early morning hours of the summer months, before the sun rises, cool air will fall from the ridgelines and down into the canyon at approximately one mile per hour. As the cool air sinks, it *flows like water* as it meanders its way to the valley floor below, even if the valley floor is many miles away. However, within one minute of the sun rising above the horizon, the ridgelines, cliff faces and peaks are heated enough to start a convection process. As the heated air rises, the cooler air from the valley floor drafts its way back up the canyon, replacing it.

If a shooter were to engage a target while aiming upwards through the cooler air at the heated ridgeline, they will experience an anomaly called superior mirage. Superior mirage does exist in a micro-environment and occurs when cooler air is underneath warmer air. The light is refracted and bent downwards, which, when commingled with magnified optics, causes the target to

be optically displaced. The effects of superior mirage will cause a high miss. At 1,000 meters, the high miss can be as much as 4.5 meters (15 feet).

Note: There are two kinds of mirage, superior and inferior. Inferior mirage occurs when heated air is underneath cool air and presents itself as ripples of water flowing on the ground surface or in the air. Superior mirage occurs when cool air is underneath the heated air and is described by the Italian term, "Fata Morgana." Fata Morgana is an optical phenomenon that occurs because rays of light bend when they pass through air layers of different temperatures in a steep thermal inversion where an atmospheric duct has formed. A thermal inversion is an atmospheric condition where warmer air exists in a well-defined layer above a layer of significantly cooler air.

When I start my classes, I use Google Earth and project images onto a screen. (This is what I did for LaBonte as I used the sunlight routine in Google Earth to view the heating and cooling of his AO/terrain throughout the day).



#### Overview of general terrain.

I begin with a master overview of an area that consists of a diameter of several hundred miles. To the south is the desert floor of Saint George, Utah and Las Vegas, Nevada, where the temperatures can reach 120°. Just to the north is Zion National Park where the temps can reach approximately 112°. Another 90 miles to the NNE is the MSC, where the average July daytime temperatures are approximately 87°. However, moving farther north and to the additional mountain tops, the temperatures are usually much cooler. If a summer thunderstorm presents itself, temperatures will drop dramatically. This overall northward cooling trend as well as altitude temperature differences; (-3 for every 1000 feet of increased altitude), makes for potentially windy conditions.

The geography is such that the

Wasatch Range runs north and south, creating a long canyon floor at approximately 5,000 feet ASL. Some of the mountain tops are at or above 11,000 feet ASL with the mountains running approximately 200 miles long. They begin near the city of Provo, Utah and terminate near a town called Kanab where the southern desert begins. Desert is also on the east and west sides of these mountains.

With the image projected onto the screen, I ask the students what do they see? Their answers are always the same. They respond by saying, "I see mountains, valleys and lakes, elevation change etc..." However, there is much/much more... There are cool water elements with temperatures below 60°, and in the desert to the south, the heated air is rising. The cooler air from the mountain tops as far as two-

hundred-plus miles to the north sinks down to the valley floor and begins its journey towards the desert. Depending on the time of the day, wind velocities of 30mph or more are the norm. Updrafts, downdrafts, and deflected currents of air flow like water. Should the southern thunderstorms present themselves, (which they often do), an incredible volume of air mass floods into the main canyon of the MSC.

Another image is projected onto the screen, as we progressively work our way into an 80 square mile area, and then to the canyon and ridge-lines where we are working. We are continually picking apart the anomalies created by the heating and cooling of the terrain, as well as optical anomalies produced by the position of the sun, the cooler air, water elements and humidity. Sounds like a



lot of stuff, and in a general manner it is. However, once an overall understanding of the movement of the air is established, the focus then shifts to the area of operation.

To obtain a full understanding and experience the reality of steep angle, high altitude, mountain shooting, the geography must be above 8,000 feet ASL. This is where the density altitude, (which is a non-linear measurement) dramatically changes. This in turn significantly changes the overall performance of the cartridge. The winds are experienced in a fashion that cannot be replicated at lower altitudes. Running the meter lines on the MSC's known distance range that is at an elevation of 9,400 feet ASL, offers the student an invaluable opportunity to obtain hard data that they cannot acquire anywhere else. The culmination of the winds, optical anomalies, altitude changes etc.... makes for the greatest outdoor classroom on earth.

One afternoon we were shooting at a target at approximately 1,200 meters. We were still in what's considered one of the mid canyon ranges at the MSC. The shooter was shooting to the northwest with open space directly in front of him. The north ridge line began approximately twenty degrees to our right with the solid wall of the south ridgeline two hundred meters directly behind us. The south ridgeline cliff face was approximately 400 meters (1,300 feet) tall.

Off and on, a tail wind was felt. When the trigger was pulled with the tail wind, the point of impact was no-

ticeably low. This was an oddity as a tail wind contributes to reduced drag on the bullet and a slightly higher point of impact. When the trigger was pulled with no tail wind, the point of impact was noticeably high. Why do you think that the point of impact changed and how can a wind come out of a cliff face?

Wind obviously cannot come out of a cliff face, although it can come from a cliff face. As there are layered winds in the mountains, there was a headwind approximately 10- to 15-feet above us. (Max ordnance was noted at 9.2 MILs or 20.6 feet above us at 683 meters). The aspen trees above and behind us showed it, and the sound and tail wind

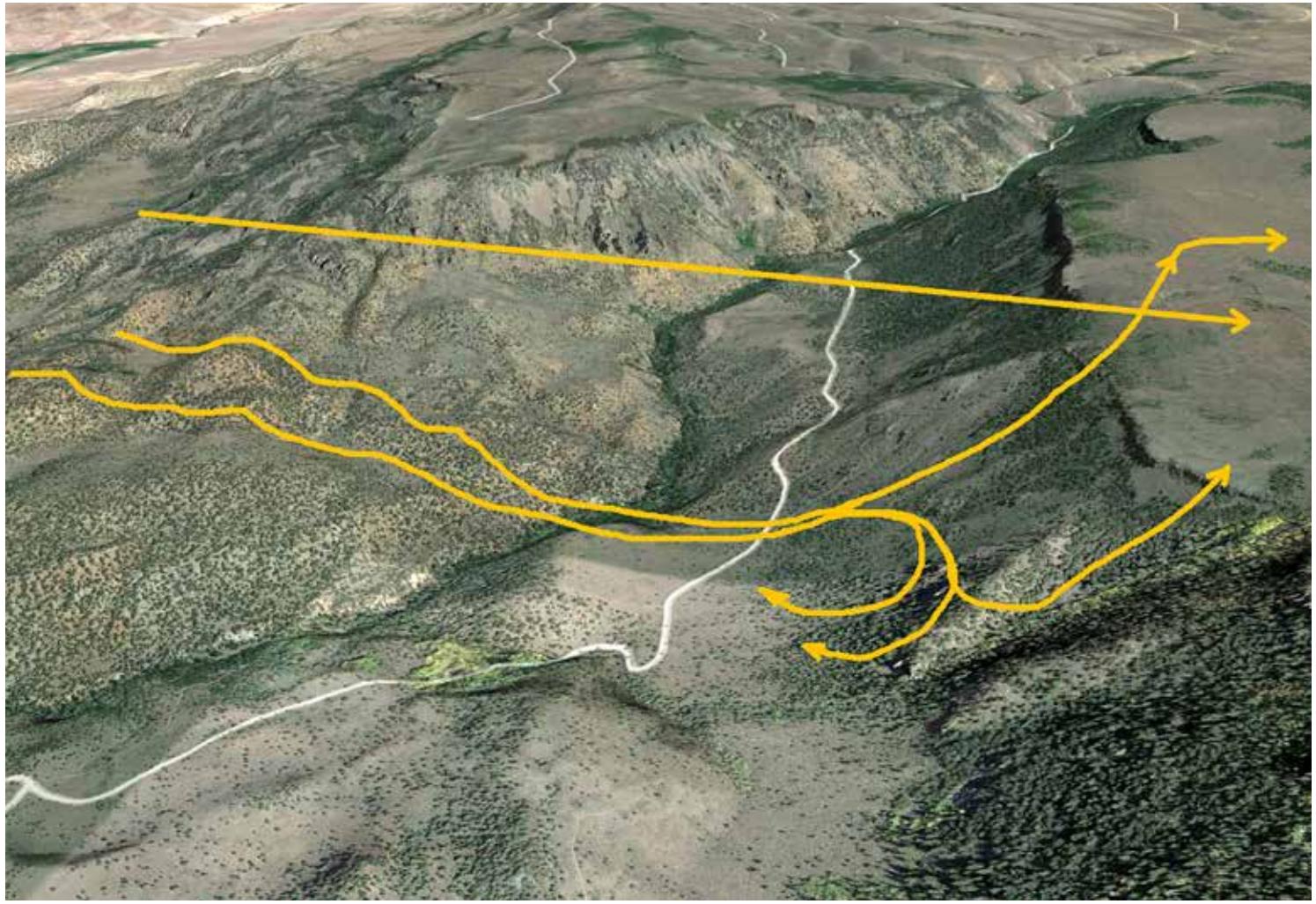
indicated it.

As the winds flowed to the south-east, the head-wind hitting the cliff face disbursed as an updraft that was then pushed in its forward flowing direction by the predominant mass of wind above and behind it.

However, other wind was forced/disbursed downwards and out towards us, which was presented in the form of a light tailwind —it's got to go somewhere. If the winds had not been layered above us, this would not have occurred. When the shooter pulled the trigger with the tailwind, the bullet climbed up towards its maximum ordnance and into the headwind, which increased the drag on the bullet, causing a changed trajectory. In addition, when the bullet was on the backside of its trajectory, the headwind pushed it even further downward. Add in a changing, low-pressure spot on the bullet, and the magnus effect contributes another downward component. Yes, the low-pressure spot on the bullet relocates to different positions on the bullet throughout its trajectory. Remove the headwind and the equation changes.

Ballistic Software such as X-Ring/AIM-E with its advanced architecture and formulas effectively correct for these types of physics/events and calculate the correct solution, however the shooter must be able to input the correct data into the software to benefit from it. In addition, data books are mandatory. Recording the evolution of the shot is imperative to catalyzing the learning experience. The notation





The wind hitting the cliff face.

of the meteorological data along with the winds, their directions, velocity, sun location and other noteworthy attributes are an invaluable learning tool. This noted data may now be utilized to assist the shooter in understanding the climatic environment they are shooting in, and help with the calculation of future engagements.

### Indicators

The main indicators that tell the shooter a wind's direction and speed are *sight, sound and physical feel*.

### Sight

I have a saying, "believe your own eyes." Seeing mirage in a mountainous environment can be difficult at times. This is because the ground temperature can be similar to or colder than the air temperature. However, if you can see it, the mirage will tell you the direction and speed of the wind. Often there's more than one mirage to focus on.

The shooter should also note movement of the trees, chaff, and bugs in the air, or other indicators. However, there is one indicator that I'll mention that I

think you will find interesting, Aspen trees. Aspens live at higher altitudes in the mountains, and during the spring and summer months their leaves are seen for miles. The bottom side of the leaf is a light green color and the top is a dark green color. When the wind is blowing away from you, the leaves will show their light color. When blowing towards you, the leaves will show their dark color. And when the wind is quartering, the color of the leaves will be mixed. The aspens will tell you the direction and speed of the wind and layers of winds all the way up the sides of the mountain and throughout the canyon. With practice, one can learn how to visualize the wind flow from a relatively far distance.

### Sound

The sound of the wind is pretty self-explanatory; however, it is not unusual to feel no wind at your firing point, yet hear the wind flowing through the canyon. The rustling of the wind through the trees or it scrubbing the rocks and cliff faces, lets you know that it is there. And with prac-

tice, the intensity of the sound can tell you its velocity.

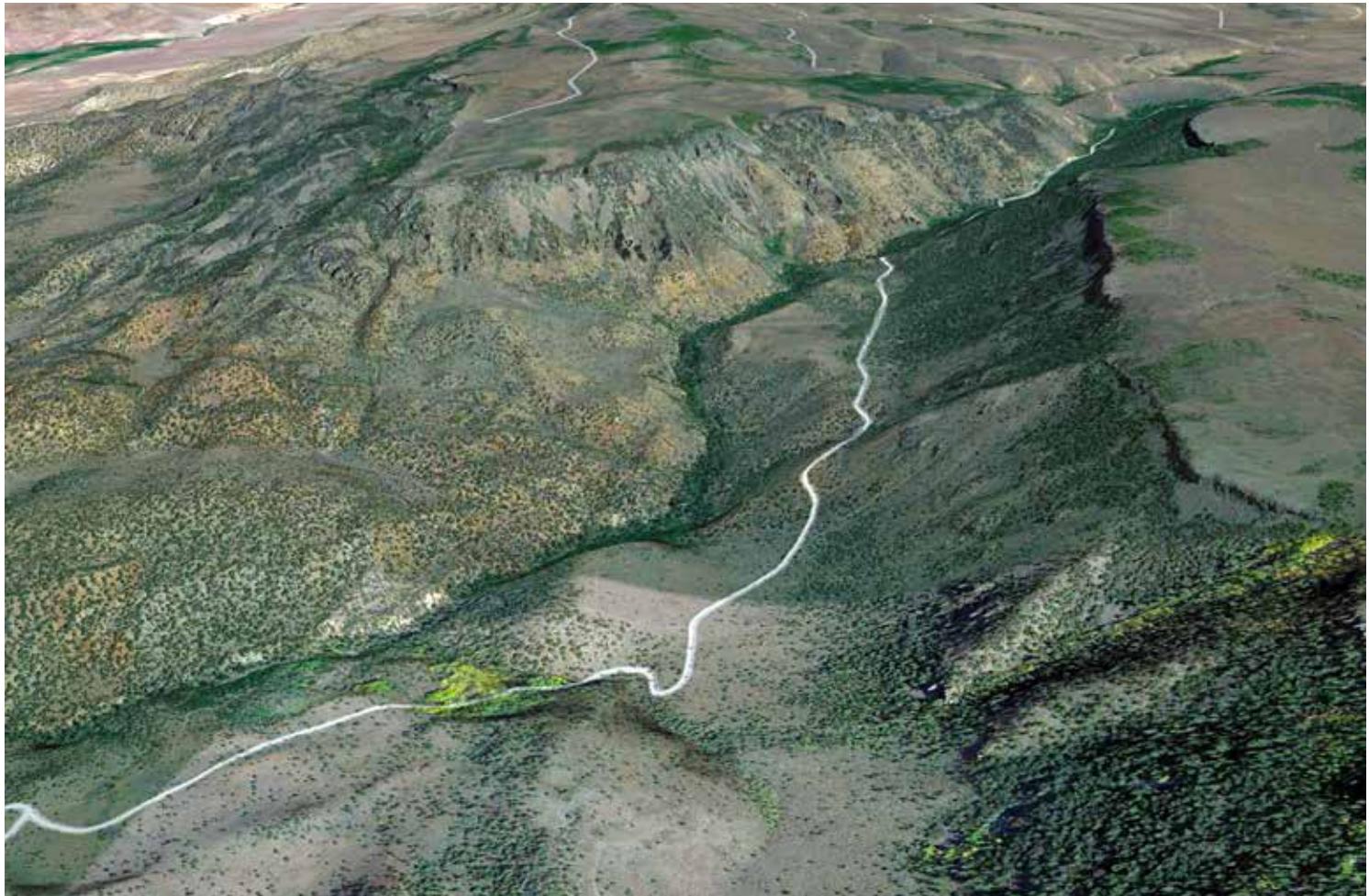
### Feel

Again, pretty self-explanatory; if you feel a light breeze on your face, the wind is blowing at approximately three mph. Locating the direction from where the wind is coming from can be accomplished by wetting the back of your ear lobes and turning your head until you feel coldness equally on both of them.

These are, in part, the tools you have to move onto the next step. Every wind has its own pattern, and at the MSC, the winds in the canyon can change every three to five seconds. Understanding the pattern will tell you why it is constantly changing.

The picture above is of the main canyon where we shoot. You'll notice the canyon is shaped in a V. The winds can and will enter at the mouth of the canyon. What do you think is happening as the wind flows from the canyon mouth to its far end where the canyon terminates into a V?

As the wind flows into the canyon,



Overview of the canyon at the MSC.

bumping into the fingers and cliff faces, horizontal and vertical patterns are created. The more wind that flows into the canyon, the greater the volume of the air and the more the air compresses and stacks up. The layer of wind above the canyon keeps the wind constrained beneath it and jammed into the canyon. Soon the air runs out of room, scrambling as it begins swirling around the boundaries as it chaotically seeks an exit. When the volume of the air creates significant pressure, more pressure than the constraining wind flowing above it, it reaches a critical point and violently escapes upwards and out of the canyon. Now the canyon is once again somewhat empty and the next cycle of oscillation begins.

The key to negotiating the winds in the mountains is to choose and shoot in the most predominant yet congenial wind pattern. This is the fun part. Once the wind pattern is chosen, the shooter uses the sight, sound and feel technique to assemble the pieces of the puzzle. This includes what the winds are doing in the middle of the canyon and at the target. When the shooter feels a certain amount of wind on

their face or neck or sees a tree next to them swaying a certain amount or hears a certain level of the sound of the wind, they assess what the wind is doing in between the firing location and the target, and at the target location itself.

Once the directions and speeds of the winds at various ranges and altitudes are calculated at the target, while at the same time matching the sight, sound, and feel indicators at the firing point, the shooter uses the indicators at the firing point as a constant when taking the shot. In other words, the shooter knows what the winds are doing at the target by observing what they feel, hear or see at their firing point. This entire process of obtaining all pertinent data is called the "anatomy of the shot."

I once watched a video of two professionals shooting at a long-distance competition. They both had the same exact rifles shooting the same exact cartridges. The shooters were using a .375 Cheytac cartridge and may have been firing a 350-grain projectile. The maximum ordnance of the bullet (the highest part of its fired trajectory arc)

was at approximately 25 feet above the line of sight and at approximately 1,050 yards. The first shooter attempted to reduce a target that was at approximately 1800 yards. These targets were approximately four feet by four feet in size. He took the first shot and missed as the second shooter took note. He took a second shot and missed as the second shooter took note. He took the third shot and hit. Then, it was the second shooter's turn. Although he took notes, he took the shot and missed. I don't know what the second shooter was notating, however as I watched them, they did not notice nor did their spotter notice a large tree just to their right swaying in what appeared to be an oscillating 12 mph wind. There is no question that the bullet was engaging a wind above them, yet it went unrecognized.

Adding up the pieces of the puzzle takes sight, sound, and feel. Those three tools along with steep angle, high altitude, mountain shooting instruction can tame the most complicated wind scenarios and greatly increase first round hits. And that's a little bit of the science behind the shooting. **SADJ**

# Long Range Gunnery Factors

By Jeff Siewert

Obtaining first shot hits at long range is the goal of every rifle shooter, but many factors can affect the bullet's flight in transit to the target. By breaking down the two categories of error encountered by all long-range shooters into individual components, the shooter can sort out what's going on, and hopefully improve the chance of placing the first round on target. This article covers the two error categories and identifies which factors go into each one of them, improving the chances for a first round hit.

## First Things First

First, a more refined definition of "accuracy" is needed for a meaningful discussion of long-range accuracy. Shooters will say they shot brand X rifle with flavor Y ammunition and the "accuracy" was 1.23 inches at 100 yards when shooting a 5-shot group with the rifle steadied on sandbags. That statement on group size for a particular set of conditions is **NOT a statement of accuracy**. Accuracy is the ability to put the average impact point of a group of projectiles on the aiming point.

The left-hand side of Figure 1 shows a group that has its average impact point nearly on the point of aim, but the group size (A.K.A. "dispersion" or "precision") is poor. In this instance, the shooter will miss the intended aiming point unless firing a very large

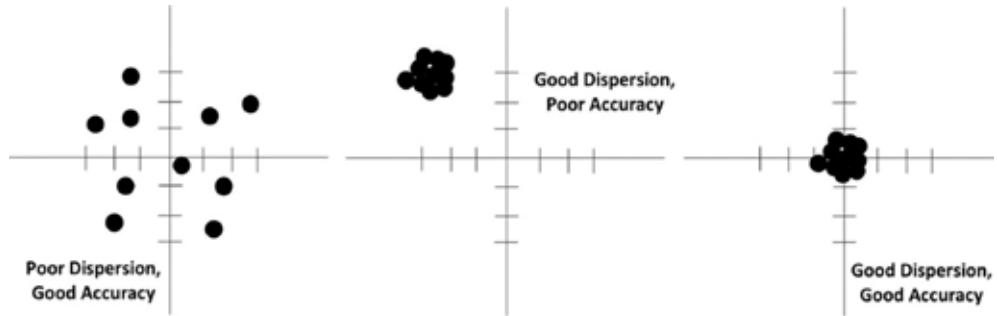


Figure 1: Definition of Dispersion and Accuracy

number of shots.

In the middle of Figure 1 is shown a typical group for a novice long range shooter who has good marksmanship fundamentals, but doesn't know how to call the wind and has the wrong muzzle velocity estimate for the load in use. The group size is small (e.g. good dispersion), but the average impact point of the fired group is significantly displaced from the aiming point in the horizontal and vertical directions. The center of the fired group is high of the aiming point, meaning the actual average muzzle velocity of the ammunition being fired was higher than the shooter's initial estimate. If the shooter can fire only one shot, the result will be a miss. But, if the shooter can spot where the shot landed, an adjustment to the point of aim can be made, allowing a hit on the second shot.

On the right-hand side of Figure 1

is the desired goal, a small group size with the average impact point of the group coincident with the point of aim. This is a group with small dispersion, where the center of impact is accurately placed.

**Table 1** lists the errors affecting group size and impact point position relative to the aim point. The "bias" errors move the whole group of projectiles, and "random" errors control the magnitude of the group size. Since the random errors are indeed random, this portion of the aiming problem causes errors which the shooter cannot correct.

Snipers and other trained long-range shooters correct fire based on the observation of impact point of fired shots.

Figure 2 shows the difference between bias errors and random errors as applied to the sniper hit problem.

Bias Effect Description	Error Factor Category	Random Effect Description
Non-zero average pitch or yaw rate causes mean point of impact (MPI) shift, can be zeroed by adjusting sights, miss is linear w/ range	Pitch & Yaw Angular Rate	Shot-to-shot variations in pitch/yaw rate magnitude & direction result in scatter in fall of shot, miss is linear w/ range
Non-zero average H or V cross velocity causes MPI shift, can be zeroed by adjusting sights, miss is linear w/ range	Vertical & Horizontal Cross Velocity	Shot-to-shot variations in H & V pointing vector magnitude & direction result in scatter in fall of shot; miss is linear w/ range
Non-zero average cross winds shift MPI in direction of wind for ballistic projectile; shift is lag time x wind. Initialization jump causes shift in vertical plane. Miss is non-linear w/ range.	Cross Winds	Shot-to-shot variations in cross wind velocity result in scatter in horizontal fall of shot. Variation in initialization jump in the vertical plane is small, also random. Miss is non-linear w/ range.
Non-zero average range winds shift MPI; headwind causes slightly hi MPI at extended ranges, effect is small. Miss is non-linear w/ range.	Range Winds	Shot-to-shot variations in head wind velocity result in scatter in vertical fall of shot, effect is small until target range gets very large. Miss is non-linear w/ range.
Non-standard muzzle velocity (REF LAT data) shifts MPI vertically depending on whether sample MV is above or below reported LAT value. Miss is non-linear w/ range	Muzzle Velocity	Shot-to-shot variations in muzzle velocity result in vertical scatter in fall of shot. Miss is non-linear w/ range
Non-standard mass/drag shifts MPI vertically depending on whether sample mass/drag is above or below reported FAAT value. Miss is non-linear w/ range	Mass/Drag	Shot-to-shot variations in projectile mass/drag result in vertical scatter in fall of shot. Miss is non-linear w/ range
Non-zero scope cant WRT bore centerline causes horizontal miss depending on scope axis misalignment; can also be caused by non-level horizontal weapon position. Miss is proportional to ballistic drop & scope cant angle.	Cant Angle	Shot-to-shot variations in vertical weapon orientation WRT gravity vector result in horizontal fall of shot scatter. Miss is proportional to ballistic drop & variation in scope cant angle.
Built-in miss angle from misalignment between scope and weapon bore centerline. Miss is linear w/ range	Boresight	Not expected to contribute significantly to random errors. Miss linear w/ range.
Miss from misalignment between target and weapon bore centerline. Miss is linear w/ range	Aiming	Miss from shot-to-shot misalignment between target and weapon bore centerline. Miss is linear w/ range
Vertical MPI shift caused by target being either closer or farther than estimated. Miss is non-linear w/ range	Range Estimation	Not expected to contribute significantly to random errors. Miss is non-linear w/ range
Vertical MPI shift caused by atmosphere being different than estimated. Miss is non-linear w/ range	Atmosphere Temp/Press	Not expected to change drastically shot-to-shot. Miss is non-linear w/ range
Target range, bearing & N/S hemisphere dependent. Miss is non-linear with range.	Coriolis/Earth Curvature	No random effect.
Not a factor w/ spin stabilized projectiles, miss is linear w/ range	Aero/Mass Trim	Not a factor w/ spin stabilized projectiles, miss is linear w/ range

Table 1: List of Bias and Random Errors Affecting Long Range Targeting

Below is discussed the factors for both the bias and random errors. The .30 caliber, 175-grain Sierra Match King projectile fired at 2650fps is used as an example for the upcoming discussion of effects of bias and random errors on the projectile flight. The errors at 500 yards, 800 yards, and 1000 yards will be examined.

### Bias Errors

For typical long-range shooters engaging targets past about 500 yards, the bias errors, in order of decreasing effect are:

- **Crosswind:** This is a wind component directly across the line of fire that is missed by the shooter/spotter. It causes an impact point shift

in the horizontal direction with the miss being in the direction of the cross wind. This error can be minimized by:

1. Use of high mass, low drag bullets fired at high velocity
2. Shooter practice at long-range reading and interpreting visual mirage cues through high pow-

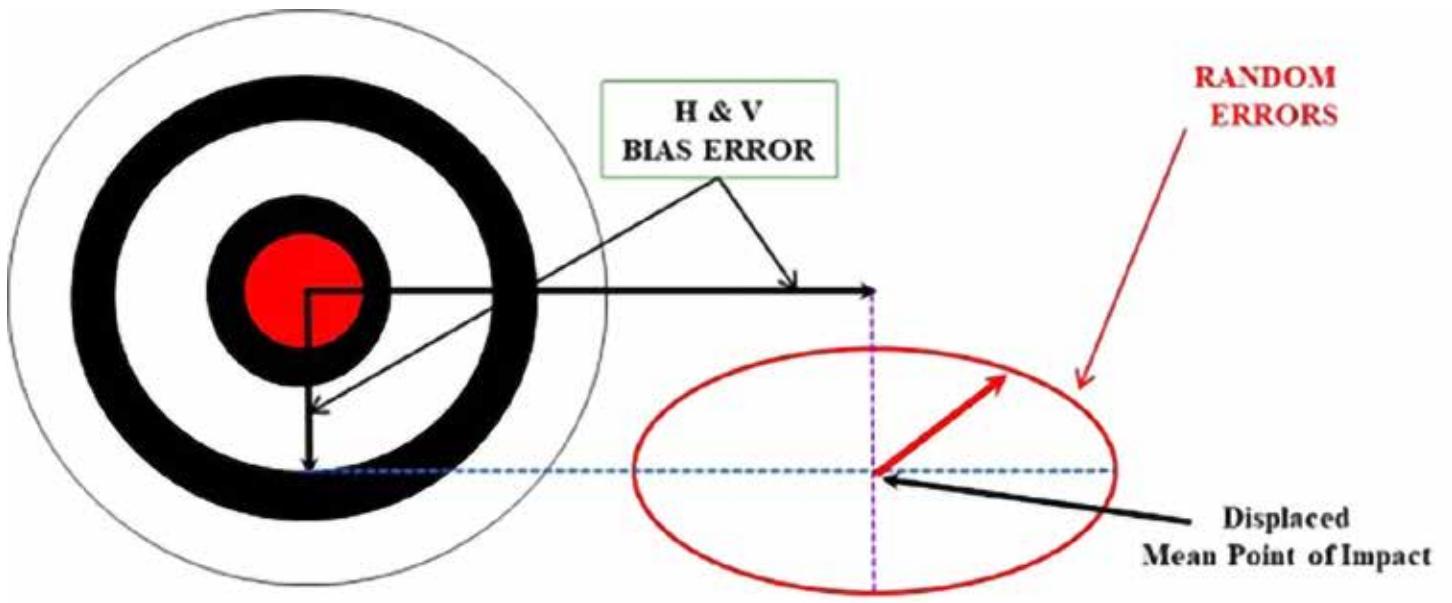


Figure 2: Illustration of Bias and Random Errors

ered optics, along with other cues like flags, leaves and limb movement on trees, etc.

Drift due to cross winds can be accurately calculated by multiplying the wind component perpendicular to the bullet line of flight by the "lag time" (the difference between the time of flight in air **minus** the time of flight in a vacuum).

- **Muzzle Velocity:** This error is caused by the average muzzle velocity of the ammunition actually fired being different than initially estimated or measured. The reason could be that the load was developed in a rifle different than is being used, an ammunition temperature shift, etc. This error causes an impact point shift in the vertical direction.

- **Range Estimation:** This error is due to an unknown target distance. This error causes an impact point shift in the vertical direction. If the target is farther than estimated, the center of impact will be low relative to the aim point. As the target range increases, the sensitivity to range errors increases, and the ability to judge distance decreases, compounding the range estimation error. This error can be remedied by use of a laser rangefinder.

- **Cant Angle Error:** This error is caused by the misalignment of the scope vertical axis with the bore centerline during scope mounting. The error causes an impact point shift primarily in the horizontal direction. The source of cant error is

Bias Error Component	Bias Error Magnitude	Factor Units
Cross Wind	5.0	MPH
Muzzle Velocity	15.0	FPS
Range Estimation	15.0	Yards
Cant Angle	0.25	Degrees
Range Wind	5.0	MPH

Table 2: Typical Bias Errors for Long Range Shooters

shown in Figure 3 in an exaggerated form for clarity.

This error can also show up in the random error column if the shooter isn't particularly fussy with the alignment of the vertical cross hairs relative to "down" shot-to-shot.

- **Range Wind:** This is a wind or wind component directly along the line of fire that is missed by the shooter/spotter. It generally has a negligible effect on the projectile trajectory at ranges under 1000 yards but is included for completeness.

- **Coriolis/Earth Curvature bias:** arises from the rotation of the Earth under the projectile during the time of flight to the target. This error is dependent on the firing azimuth, latitude of firing and target positions, the hemisphere (north vs south) of the shooter, as well the time of flight to the target.

- **Cross Velocity and Angular Rate bias:** errors have been placed at the bottom of the bias list because if they are present, the shooter zeros these

errors when the scope is adjusted to hit the mean point of impact.

Table 2 lists the bias errors for the long-range shooter and typical values for each of these errors.

### Random Errors

Random errors cause increases in group size about an average group impact point that is potentially displaced from our aiming point by the vector addition of the bias errors. The random errors long-range shooters have to worry about in order of decreasing importance are:

- **Crosswind Variation:** This is shot-to-shot changes in cross wind along the bullet path as the group is fired. It affects group size in the horizontal direction.

- **Muzzle Velocity Variation:** This is the shot-shot muzzle velocity changes that cause the group size to increase in the vertical direction because the lower velocity bullets take a longer time to reach the target and drop more.

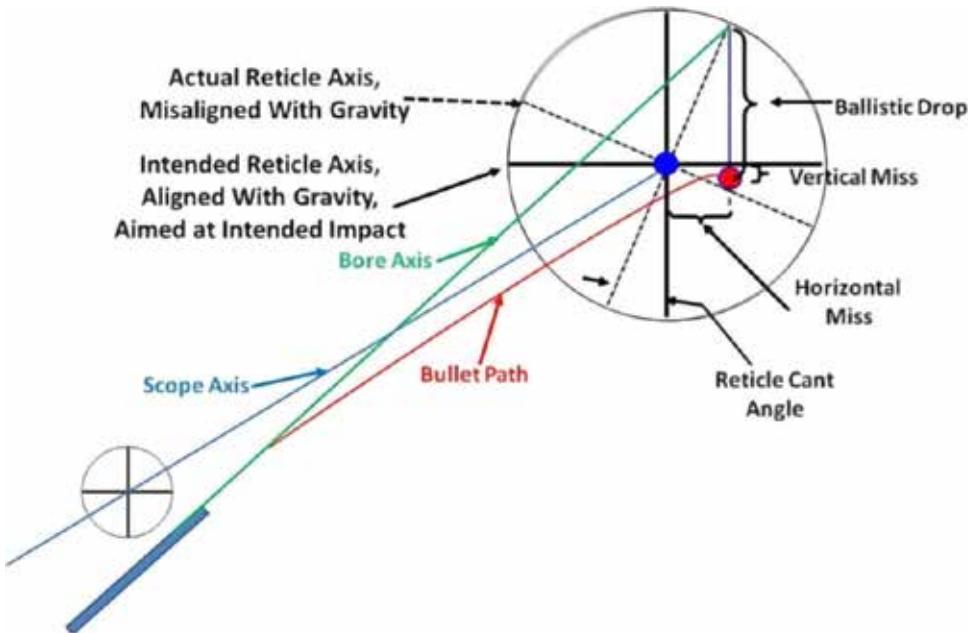


Figure 3: Cant Error Details

- Drag/Mass Variation:** shot-to-shot changes in projectile drag and/or weight. As the bullet flies down range, air resistance slows it down. If there are changes in drag or projectile weight from bullet-to-bullet, vertical "stringing" of the shot group results. From Doppler radar tracking, shot-to-shot variation in drag of about 0.5-1.5 percent is unavoidable.
- Pitch Rate:** Affects projectile group size (dispersion) in the vertical axis at short range.
- Yaw Rate:** Also influences projectile dispersion, it affects group size in the horizontal direction at short range.
- Cant Error:** This error is the shot-to-shot error the shooter makes in aligning the vertical axis of the aiming device with the local gravity field (down). This error affects group size mostly in the horizon-

- tal direction.
- Aim Error:** This is the inability of the shooter to precisely line up the aiming device with the intended target from shot-to-shot. This error affects group size in both vertical and horizontal directions. Every shooter has these, and they might be quite large depending on the shooter's skill and position (off-hand is largest, prone is smallest).
- Boresight Variation:** This is the inability of the shooter to locate his/her eye in a repeatable manner behind the scope, affects both group size in both the horizontal and vertical directions.
- Mean Point of Impact Variation:** This is a variation in the average impact point group-to-group due to statistical sampling of the ammunition lot while firing a particular shot group. The average impact point variability is a function of the

average group size and the number of shots fired. The "sampling" that occurs when we fire a group of bullets causes the location of the group center of impact location to jump around in both the horizontal and vertical direction.

- Range Wind variation:** This is shot-shot changes in head wind, and it affects group size in the vertical direction a minor amount out to one kilometer.

Table 3 lists the magnitude of the random errors for a typical precision rifle, based on engineering estimates of the various errors measured errors for system dispersion, typical measured muzzle velocity variation, and extracted drag variation. The remaining errors are small and the values are estimates partly based on the magnitude of the bias errors.

If the horizontal and vertical orientation of fired groups at short range doesn't average out to be approximately the same in both directions over the long haul, there's something wrong with the rifle, the device holding the rifle, the shooter or a combination of all of the above.

By the way, it should mentioned that **ALL** of these errors either stay the same (in terms of angle) or grow with increased range, they **NEVER EVER** get smaller. The refrain: "Oh yeah, it's a 1-MOA rifle at 100 yards but once the bullets "settle down", it's a  $\frac{3}{4}$ -MOA rifle at 200 yards and beyond" is common, but incorrect. In a nutshell, it can't happen. When that claim is made, it's always based on separate groups fired at different distances. Ask any bullet maker who takes group size data at 100 yards and 300 yards simultaneously for each group they fire, they'll tell you that the 300-yard group is three times larger than the 100 yard group (or larger), but they'll never say it's smaller in terms of angle at the longer range. For group sizes to get smaller in terms of angular measurement with increased range, some mystical entity would have to exist that: A) knows where the bullets are going as they leave the gun and, B) is capable of steering them back on course as they travel down range. God, has much more important things to do than babysit the bullets from your rifle on their way to the target.

Shown in figure 4 is a plot of the bias errors for a 175-grain Sierra Match King

Random Error Component	Random Error Magnitude	Factor Units
Cross Wind Variation	1.0	MPH
Pitch Rate Variation	10	rad/sec
Yaw Rate Variation	10	rad/sec
Cant Angle Variation	1.0	Degrees
Muzzle Velocity Variation	15.0	FPS
Drag/Mass Variation	1.6	Percent
Aim Variation	0.10	MRADs
Boresight	0.05	MRADs
Range Wind	1.0	MPH

Table 3: Typical Random Errors for Long Range Shooters

## .30 Cal, 175g Sierra Match King:

### Bias Error vs. Error Source & Range

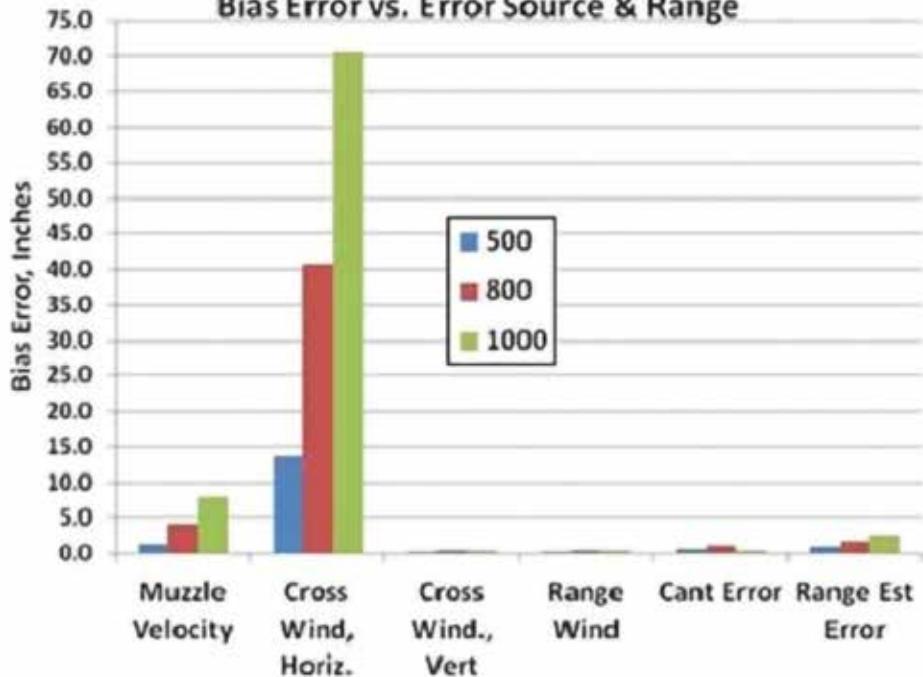


Figure 4: 175grain, .30 cal. Sierra Match King Bias Error vs. Error Sources and Range

bullet fired at 500 yards, 800 yards, and 1000 yards for the error budget values shown previously in table 1. It's easy to see that for the error values chosen, crosswinds rule the roost when it comes to bias errors. Muzzle velocity shift comes in a distant second. The sensitivity of bullets to crosswind at extended ranges causes accomplished shooters to develop the skill to "read

the wind". In table 1, the crosswind bias was 5 MPH, and the data shown here assumes the wind is constant for the whole trajectory. Comparing the crosswind effect at 800 yards to 1000 yards (only a 25% increase in range), a 75% increase in crosswind error is seen.

Figure 5 shows the random errors for the .30 caliber, 175-grain Sierra Match King bullet using the random errors in

## .30 Cal, 175g Sierra Match King:

### Random Error vs. Error Source & Range

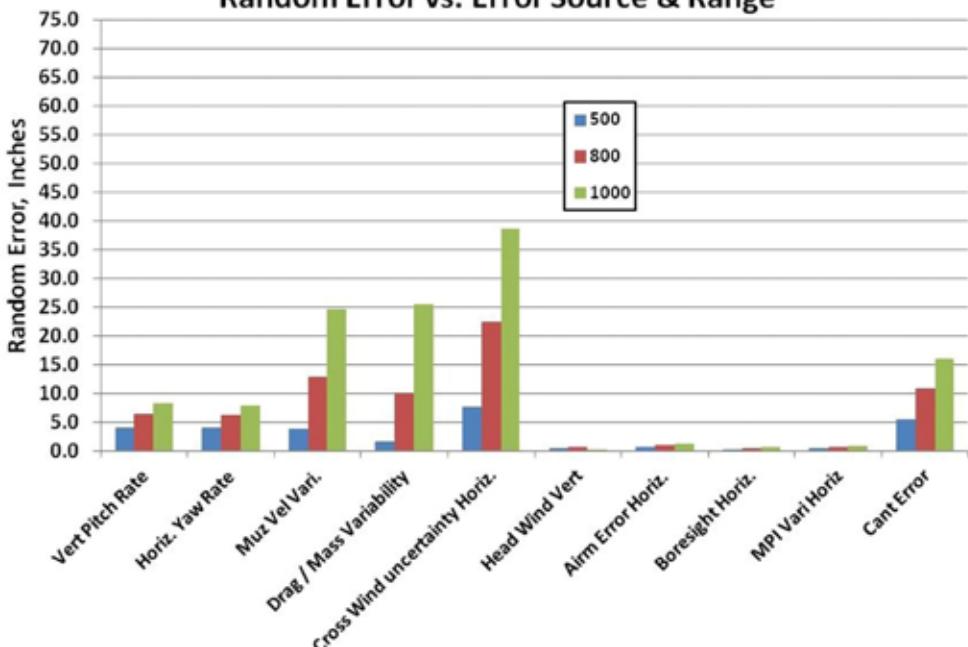


Figure 5: .30 cal. Sierra Match King Random Error vs. Error Source and Range

table 2 with the same error scale used for figure 4. Comparing the errors, the variation in crosswind (at 1 MPH) is the largest factor, followed by the drag/mass variation and the muzzle velocity variation, which are nearly the same size at equal ranges. Also, the shot-to-shot cant variation of 1-degree is increasingly important as the target range increases.

So, how does a dedicated shooter reduce the bias and random errors to improve hits at extended ranges? It makes logical sense to attack the largest errors first, so start with minimizing the largest error budget component beyond 300 yards, namely crosswinds. To minimize the effect of crosswinds, choose a heavy bullet with low drag (A.K.A. high ballistic coefficient), and launch it at as high a velocity as possible. Looking at the vertical and horizontal pitch rate errors shown in figure 5, it could be smart to trade a small increase in group size for increased muzzle velocity or a drag reduction. That muzzle velocity boost has a direct effect on reducing the crosswind effects, but it also helps reduce the errors from muzzle velocity variation, cant variation and range estimation.

Beyond this, the next most important improvement the long-range shooter can make is to use a chronograph to get an accurate measurement on both the average muzzle velocity and the variation in muzzle velocity for his/her loads. While most commercially available chronographs do a creditable job of measuring the average muzzle velocity for rifle ammunition, the accurate measurement of the muzzle velocity variation can be a tall order. The reason for this is most hobby chronographs have a screen spacing that is too short, combined with too slow a clock speed, to measure the muzzle velocity with sufficient accuracy to be able to conclusively prove a smaller shot-shot muzzle velocity variation than the previous load. Newer commercial devices, such as those using magnets and radar, do a better job in this department than traditional, screened chronographs, however.

To summarize, the error budget approach to dispersion will give you an understanding the difference between the bias and random errors at long range, provided you're collecting data (e.g. muzzle velocity) during your shooting. **SADJ**



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# TRB RS9 Vampir

## Bosnia's first service pistol

Story by Pierangelo Tendas | Photography by Nebojša Tatomirov

**R**epublika Srpska ("Serbian Republic", not to be confused with the Republic of Serbia!) is the easternmost of the two political entities that currently compose the State of Bosnia and Herzegovina – a Country born from the wreckage of the bloody wars that swept the Balkans in the 1990s.

By far the most war-scarred nation of the area, Bosnia is still working to

rebuild its infrastructure. This process led to the rebirth of a fledgling, but promising, military industry—a must-have for any self-respecting country. Before the breakup of Yugoslavia, Bosnia was already home to some plants of the military-industrial complex of the socialist federation, most of which were focused on equipment, ammunition, explosives, and sighting devices.

The joint-stock company TRB - Tehnički Remont Bratunac A.D – headquartered in the city of Bratunac, in the Republika Srpska, not far from the border of Serbia proper – is arguably the most advanced military industrial entity in modern-day Bosnia and Herzegovina, working on anything from fuses for mortar shells and artillery rounds to machinery for small and medium caliber ammu-



Hailing all the way from Bosnia and Herzegovina, the RS9 Vampir is manufactured by TRB (Tehnički Remont, A.D.), headquartered in the city of Bratunac, Republika Srpska.



The TRB RS9 Vampir boasts a full metal construction, departing from the modern day trends of polymer frames.

tion, down to mine and ambush protected vehicles (the "Despot" MRAP being a key product in TRB's catalog) and higher-level technology pieces of military hardware such as radars, biometrical access nodes, mobile security systems, and more.

Up until recently, the bulk of TRB's experience in the field of small arms consisted in the overhauling, repair, and restoration of firearms for both civilian and government customers. The RS9 Vampir represents their first

foray in small arms manufacturing – and a good one at that: a solidly built service pistol, hailing from the most unlikely of places.

#### A new take on an old design

An expert eye will not struggle to see the similarities between the RS9 Vampir – the first handgun to be manufactured in Bosnia and Herzegovina – and the Zastava CZ99, first introduced in 1989 as a service pistol for then-Yugoslavia, and now well

into its fourth generation.

That, to us, is nothing to be ashamed of; the CZ99 is a solid, sturdily built, good performing pistol that still enjoys the appreciation of both the commercial market *and* professional operators worldwide, and whose lineage left a profound mark on the military industry of the countries that were once part of the Socialist Federal Republic of Yugoslavia. Handguns such as the Slovenian AREX REX Zero1 and the Croatian



The RS9 Vampir is the first – and so far only – firearm manufactured by Tehnički Remont Bratunac.

HS-95 owe their own existence to the CZ99.

Largely due to the fact that Tehnički Remont Bratunac had to industrialize from the ground up to manufacture this pistol, however, it must first and foremost be pointed out that the RS9 Vampir shares absolutely no parts commonality at all with the CZ99 or any of its clones, and is not compatible with any component of the former – not even the magazines.

Going straight to the point, the TRB RS9 Vampir is a semi-automatic, locked-breech, short recoil operated pistol chambered in 9mm Luger, featuring a modified Browning locking system with a single lug that allows the barrel to engage the slide around the ejection port area.

The frame of the Vampir is machined out of a solid billet of 7075-T6 aircraft-grade lightweight

aluminum alloy – also known as ERGAL-55 in Europe – while the slide is manufactured out of the same chrome-moly steel used for the polygon-rifled 4.2-inch barrel.

The grips are manufactured out of a blend of polyamide and a styrenic thermoplastic elastomer (essentially an industrial-grade rubber) known as Kebaflex, and available in different checkering patterns. Smaller parts such as the trigger, hammer, and various levers, are metal injection-molded out of steel – still the best, most cost-effective way to obtain such small components for a large-scale manufactured service pistol.

The breechblock is manufactured as a separate, all-steel component, and is secured within the slide assembly by a cross-pin. Sights are fixed, dovetailed to the slide: the rear sights feature two high-visibility white dots, while the front sight features a clear, easily distinguished white triangle inlay. The sight radius is 6.3 inches long, pretty standard for a full-size service pistol, providing easy alignment.

#### Born out of experience

The balance between those features on the RS9 Vampir that retain the CZ99 lineage and those that depart from the tried-and-true Serbian model appears to have been carefully calculated out of a high level of first-hand experience with the platform, so much so that today the RS9 Vampir is arguably more advanced as an evolution of the CZ99 platform than its current iterations manufactured by Zastava Arms.

The RS9 Vampir features a SA/DA trigger, with no manual safety, and a decocking lever which also doubles

as a slide hold-open release catch in order to minimize the number of controls.

The slide stop and manual decocking lever on the RS9 Vampir is much smaller and a little bit more recessed if compared to that of the CZ99; it is located farther back over the grip if compared to the same component on the Serbian pistol, and only on the left side.

The overall design of the RS9 Vampir is a little bit more streamlined than the current Serbian-made iterations of the CZ99: both pistols stand at the same level in terms of length, width and height – with a handful of millimeters of difference – which also means that they share the same bore axis, more or less.

The RS9 Vampir is however far less boxy, with its rounded, serrated trigger guard, chamfered front portion of the frame and likewise lightened slide to make it less prone to snagging during speed draws. Basically all the sharp angles that the original CZ99 is known for have been lightened; this also includes a shorter dovetail.

The overall slimmer design will remind many older shooters of another European high-quality gun of times gone by – the Swiss-made ASAI OnePro, also designed and built with fast action in mind.

With a trigger weight ranging between 12 pounds in double action and 4.8 pounds in single action, the RS9 Vampir is in the same league as the vast majority of service and defensive pistols out there: a quite consistent trigger pull, remarkably smooth in double action and providing a good, crisp break which is pretty noticeable in single action.

The RS9 Vampir comes with a MIL-STD 1913 Picatinny rail portion underneath the dust cover for tactical accessories – something the original CZ99 did *not* feature before its fourth and current generation, the EZ9.

### Remarkably sturdy

The TRB RS9 Vampir strips down just like any SIG Sauer P226 or CZ99 variant: with the magazine



The baseline, full-black version of the RS9 Vampir: despite being a CZ99 variant, it is not compatible with any component of the original Serbian pistol.

removed, the hammer down and an empty chamber, the user locks the slide open with the slide stop catch and turn the takedown lever located on the left side of the frame 90 degrees clockwise, from its standard 3-o'clock to a 6-o'clock position; releasing the slide stop will then allow the user to separate the slide from the frame, subsequently removing the barrel and the return spring – which is conveniently captive on its guide rod.

Additional disassembly – not required unless the user needs to go beyond standard cleaning and maintenance – requires the use of a pin punch to remove the breechblock

from its seat in the slide and a small flat-headed screwdriver to detach the trigger group from the frame. The grips are held in place by Torx screws.

The CNC-machined, tapered locking block located within the slide is easier to remove, and comes out as soon as the takedown lever is pulled from its channel.

What's immediately obvious when handling the RS9 Vampir is the remarkably good quality and execution. Aside from using state-of-the-art CNC machinery and other cutting-edge manufacturing technologies – something not all western observers are still quite used



to expect from a gun manufacturer from the Balkans, outside of the biggest players such as Zastava, HS Produkt, or AREX – it is clear by handling the RS9 Vampir that the people at TRB take pride in what they do, and have enough experience and familiarity with the CZ99 design to know how to make it better.

To make it even more durable, TRB decided to go for a ceramic-based outer coating instead of your standard blued finish – for most variants, anyway. The black version will still feature a hard-anodized matte black frame, but with a black Cerakote finish on the slide. The “Inox” variant features a polished stainless slide and a Cerakote matte white frame. All other versions – olive drab green, desert tan, and bi-tone – feature a full Cerakote finish on both frame and slide.

Distinct from the standard versions, the RS9 Vampir Lux model – a deluxe variant specifically for civilian sales – can be told apart by its full matte black finish, gold-inlaid markings, and its set of black Duralumin grip panels with an embedded gold medallion featuring the TRB company logo.

Common to all variants are the checkered grip front- and backstraps; a low-profile, checkered magazine release button located on both sides of the frame – at convenient thumb reach for either left-handed or right-handed shooters, the only ambidextrous control featured on the RS9 – and a double-stack metal magazine offering a solid 18-round capacity.

Magazines for the RS9 Vampir are manufactured and provided to TRB by MEC-GAR of Italy, one of the world's biggest and most respected manufacturers of small arms magazines. MEC-GAR magazines are used by the bulk of best-known handgun makers around, including all the bigger names in the industry; should the RS9 Vampir hit the international civilian markets, this would guarantee a steady supply of aftermarket spares.

All magazines feature an extended black polymer floorplate, for a bet-

ter grip and to better withstand impact with the ground in case of an emergency reload without magazine retention. On the RS9 Vampir Lux, the floorplate is made of black Duralumin.

Aside from the standard 4.2-inch service barrel, the RS9 Vampir is also available with other barrel options, including extended and threaded barrels for silencers or muzzle brakes, and compensated barrels for competition shooting. The markings on the slide can be in Latin or Serbian Cyrillic, depending on the version and the reference market (national, eastern Europe, global exports).

### Up there with the big boys (?)

The first prototypes of the RS9 Vampir pistol were showcased at the 2017 edition of the PARTNER expo in Belgrade, Serbia; the finalized product was announced in early 2019 and showcased that same year at IDEX in Abu Dhabi. By 2020, the RS9 Vampir had been officially adopted by SAJ, the Special Anti-terrorism Unit of the Police of Republika Srpska.

In 2017, it was suggested that the RS9 Vampir would be proposed as the new standard sidearm for the Armed Forces of Bosnia and Herzegovina whole, where it would replace the Zastava CZ99 pistols that are still in use, most of which being leftovers from the old Yugoslavian National Army.

So far, said full-scale adoption hasn't materialized; with the ongoing tensions between the local authorities of Republika Srpska and the central government of Bosnia and Herzegovina – with the former seeking increased autonomy from the latter – whether or not it will actually happen, at least on the short term, is anyone's guess.

And that's too bad, if you ask us, because the RS9 Vampir appears to be a solidly built product, and is definitely the most advanced variant of the CZ99 platform currently in production, given how Zastava's own PPZ modular/multicaliber pistol design – also known with the previous prototype names of M-07 and "Rashomon" – has gone dark since



The RS9 Vampir pistol in its desert tan camo variant.



The olive drab version of the RS9 Vampir pistol.



The RS9 Vampir pistol in its stainless version, with a polished slide and a ceramic-coated matte white frame.



One of the many bi-tone versions of the RS9 Vampir: matte black frame, desert tan slide; this one features an extended, threaded barrel with a muzzle protector.

the 2012 edition of IWA and is considered by many to be dead in the water (*if Zastava wants to provide us with proof of the contrary, we'll be happy to hear from them!*).

The only pistol the RS9 Vampir actually compares with, among those hauling from the Balkans, is the REX Zero1 manufactured by AREX in Slovenia. The two designs share a full-metal construction – which is tantamount to reduced recoil and is guaranteed to appeal to those shooters and operators who *still* don't fully trust polymer-frame pistols – but the RS9 Vampir is definitely more streamlined than the boxy REX Zero1, and simplified in terms of controls.

On the other hand, the RS9 Vampir is so far available in one single baseline design – with the variants distinguishing themselves by finish and barrel configuration – while the REX Zero1 is available in compact, tactical, competition, and optics-ready configurations, as well as in calibers other than 9mm for some markets.

It would be extremely interesting to test the two pistols head-to-head – potentially along with Zastava's own, "original" CZ99 – and see how they fare in terms of performance, handling, and reliability. Unfortunately, while being available for private purchase in its homeland of Bosnia and Herzegovina as well on the Serbian civilian market, the RS9 Vampir still hasn't debuted on the western commercial markets, where its success would depend on a vast array of factors, including – but not limited to – the price per unit and the availability of dedicated or compatible accessories and other accoutrements.

In 2021, the pistol was once again showcased by TRB at several defense trade shows: PARTNER in Belgrade, IDEX in Abu Dhabi, and EDEX in Cairo, Egypt.

Its features – including the price tag for bulk orders, considering the country of manufacture – could be great selling points for the RS9 Vampir as a 21<sup>st</sup> Century service sidearm for emerging countries, many of which are notoriously in dire need



The RS9 Vampir Lux variant, built for collectors, features gold inlaid markings and a gold medallion with the TRB logo in the Duralumin grip.

of modern weaponry as they face both budgetary constraints for their security forces *and* exponentially growing threats of terrorism, internal turmoil, and organized crime. So far, however, no exports of the RS9 Vampir towards professional/mil/LE/govt. customers worldwide can be confirmed.

Nevertheless, the TRB RS9 Vampir undoubtedly represents a rewarding endeavor for the defense industry of a country that, following the violent breakup of Yugoslavia, was left with basically no small arms manufacturing capabilities to speak of; a country which, for better or worse, was capable to build its own, and seemingly at a fairly high level of technology and skill. Here's to greater heights!! **SADJ**

#### TECHNICAL SPECIFICATIONS

Manufacturer:	TRB - Tehnički Remont Bratunac A.D.
Model:	RS9 Vampir
Type:	Semi-automatic pistol
Calibers and twist rates:	9mm Luger (1:10in)
Action:	Semi-automatic, locked-breech, short recoil operated
Trigger system:	SA/DA
Safety:	Manual decocker, firing pin safety
Capacity:	18-round, double-stack magazine
Sight systems:	Fixed high-visibility three-dot front post and rear
Barrel length:	4.2in
Total length:	7.67in
Weight (empty):	1.8lbs, without magazine
Materials:	Machined aluminum grip frame; chrome-moly steel barrel and slide; polyamide and Kebaflex grips; metal magazine with polymer or Duralumin floorplate
Finishes:	Numerous ceramic-based and anodized finishes available



The RS9 Vampir strips quickly and easily; unlike other CZ99 variants, its recoil spring is captive on the guide rod.



The RS9 Vampir features no manual safety; a manual decocker, also doubling as the slide stop lever, is located just above the left grip panel.

Portuguese Army soldier fires  
a less lethal cartridge from the  
Benelli Super Nova.





# Port Arms

By Bryan Ferreira

# The Portuguese Army's New Benelli Super Nova Shotguns

**S**hotguns have been around the battlefields of this world for a long time, and even though we have seen some major evolution in their design, functionality, and even advances in technique and tactical employment, their capability to shoot 12-gauge ammunition of the most diverse loads we can imagine has not changed. From the rending capability of the 00-buck, to the use of less lethal rounds with salt and other improvised materials, the shotgun will fire anything that fits inside the shell.

Military shotguns were historically used in the past century mainly in three roles, trench warfare, jungle patrol, and prisoner security. This has changed a bit over the years as the assault rifle took over most of these roles and shotguns have been seen as a secondary, or even tertiary, weapon. Today, we mostly see shotguns being employed as breaching devices or in crowd riot control, but for the Portuguese Army these weapons will also have additional missions; for example, critical infrastructure security and shooting down low flying unmanned aerial systems (UAS).

In the use of military shotguns, Portugal has some experience with these in the past. In the 1960s and 70s Portuguese elite units used shotguns in the wars that developed in their overseas territories in Africa. But these were non-standard weapons issued without any logistical channel and with no parameters at all. So, having this in mind and extending this knowledge to new roles of the present, the Portuguese Army has recently acquired their last missing piece of hardware in what relates to their small arms modernization program. After the tenders at NSPA



(NATO Support and Procurement Agency) for assault rifles, machine guns and grenade launchers, which

FN Herstal won, followed another tender for a sidearm, won by Glock, and now, combat shotguns with



Combat Shooting Instructor João Cortesão, instructs Portuguese Army personnel on how to stack up in teams with their new Super Nova shotguns.

Benelli Defense smashing the competition. Since December 2020, the Portuguese Army has been equipping

its soldiers with hundreds of pump action Benelli Super Nova shotguns and it has been a huge success.

When I was invited by Benelli Defense to visit their factory in the beautiful city of Urbino, Italy, I would



have not imagined they had such remarkable facilities. This is a small ancient city that has been producing guns for centuries, but the Benelli Defense facilities have nothing old about them. We are talking prime

technology in weapons manufacturing where robotization blends with human manual labor and having research and development as a priority in the company's plans. After this visit to the factory — and being that

me and my good friend João Cortesão were hired by Benelli Defense to be the lead instructors for the shooting courses that were included in the NSPA contract with the Portuguese Army — we received armorer-level





instruction on the weapons in order to be able to resolve any issues that might come up during training and provide the proper maintenance to the weapons.

The Super Nova shotgun permits

simple field maintenance, without any tools, and if any other more complex maintenance is required, anyone can do it with simple training and some regular tools.

As for the shooting performance,

it's an awesome gun with excellent reliability and the ergonomics adapted to modern combat. The Portuguese Army opted for a 14-inch barrel which gives it the best of both worlds. You can still have excellent



fighting capability with its rounds burning a lot of powder inside the barrel and giving it good ballistic performance. At the same time, with its collapsed buttstock, it's compact enough to carry as a backup gun or breeching tool. The guns came in Coyote color and can be loaded with four cartridges in the magazine tube, plus one in the chamber.

As major enhancements for this weapon, we choose two design features, the extended size sliding fore-end and the control that stops the magazine feed to the chamber. The first is especially important for small sized personnel who have shorter arms, and with this, can easily manipulate the pump action of the shotgun. The second is a unique capability that, for now, you can only find on the Benelli Super Nova. It allows you to stop the feeding process and load a different cartridge into the chamber without any complex procedures. This can be very useful in some situations where the user has to switch loads from the one in the magazine tube (ex. buckshot to slugs, bean bags to CS, etc...).

Over the past months, as contracted by NSPA, we managed to provide several courses to different groups of soldiers within the Portuguese Army. The instruction was divided into theoretical-practical components of mechanics and maintenance, which addressed the characteristics of the weapon, assembly and disassembly, weapon parts and their functions, teardowns and maintenance at the user level. In the practical component of combat shooting with a shotgun, it included, among others, the following training actions:

- Types of ammunition available.
- Ballistic trajectory of the various projectiles and respective ballistic effects in situations of covert and/or concealment (vehicles, walls, doors, etc.).
- Tactical use of a shotgun in the most varied combat situations.
- Shotgun shooting techniques (either with lethal or less-lethal ammunition).
- Load and reload in combat.
- Transition between various types of cartridge with the loaded weapon.
- Shooting on the move with quick reloading.
- Team tactics and shotgun firing in





Portuguese Army Commandos train  
using team drills with their new  
Super Nova shotgun.



Combat Shooting Instructor João Cortesão demonstrates to Portuguese Army personnel how to work with their new Super Nova shotgun.

close quarters.

- Resolution of shooting malfunctions.

At the end, military trainees are capable of firing five rounds, with 40 to 50 projectiles of 00-buckshot in less than four seconds, and then manage to reload the weapon very quickly. This is a capability that is very hard to match on any other firearm, and it gives these soldiers a lot of firepower in any battle. But that is not enough, as famous Instructor and my good friend James Yeager says,

"you can shoot as fast as you pull the trigger, but you can only hit as fast as you aim." So, any gunfighter needs to dominate all other aspects of combat shooting with a shotgun, and that was what these military accomplished. It was deeply rewarding to watch the trainees going from very little experience to professional-level use of this gun. Even though it's a remarkable tool with unparalleled, multipurpose capability, the shotgun is not a friendly weapon to use, and it doesn't leave a lot of

space for mistakes.

The Portuguese Army has made an excellent choice, not only because Benelli Defense is probably the premier manufacturer of shotguns in the world, equipping military forces from all over (including several NATO armies, where the United States stands out with the Benelli M4 and the French, also with the Super Nova model), but because this weapon is in fact one of the best modern pump action shotguns on the market. **SADJ**



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Figure 1: Ruger #1, manual feed system.

# Feeding the Beast

## An Overview of Gun Feeding Systems

By Jeff Siewert

**T**yically, ammunition feed system design is closely linked to the design of the cartridge and host weapon. Cartridge design is driven by several factors; working from the target backwards to the launcher, these factors are terminal effects, hit probability, engagement range, barrel length, muzzle velocity, and peak pressure. When considering rifle or machine gun cartridges, the sleek ogives (nose) of projectiles used in cartridges for long range engagements also help facilitate feeding and chambering of these cartridges. These cartridges tend to operate at peak pressures around 60,000 PSI (400 MPa), making reliable seals and extraction of fired cases a primary consideration of cartridge case design (See SADJ, vol. 13, no. 1). Metallic cartridge cases in high performance applications typically employ a tapered exterior to facilitate extraction after firing. Cases for high

performance weapons are typically subjected to high internal pressures, generating stresses well above the yield strength for the case material. The case body taper permits removal of residual stresses between the case and chamber with only a small movement of the case aft of the fully locked position. The case body taper aiding extraction also facilitates feeding and chambering functions. The recent advent of polymers for cartridge cases reduces the need for a steep case body taper as the yield strength of polymer is considerably lower than it is for common metallic case materials. The reduced yield strength of polymer cases results in a reduction in residual case-chamber stress and friction, thereby easing extraction.

With weapons intended for close-range engagements, more effort is spent on bullet terminal performance and considerably less on trajectory

performance. This leads to bullet designs with more blunt and shorter ogives, which can be a challenge to feed reliably. The reduced emphasis on trajectory performance typically leads to a reduction in peak chamber pressure for the weapon, reducing the residual post-firing stress in the cartridge case wall, thus reducing the need to taper the case body to facilitate extraction.

For purposes of this article, clips are metal framework containers that only partially enclose the cartridges and draw their feed energy from mechanisms outside the cartridge container, while magazines completely enclose the cartridges they contain (except for those being immediately fed into the gun) and possess a spring or other internal mechanism to push the cartridges toward the feed position.

The gun operating principle imposes energy requirements and limitations

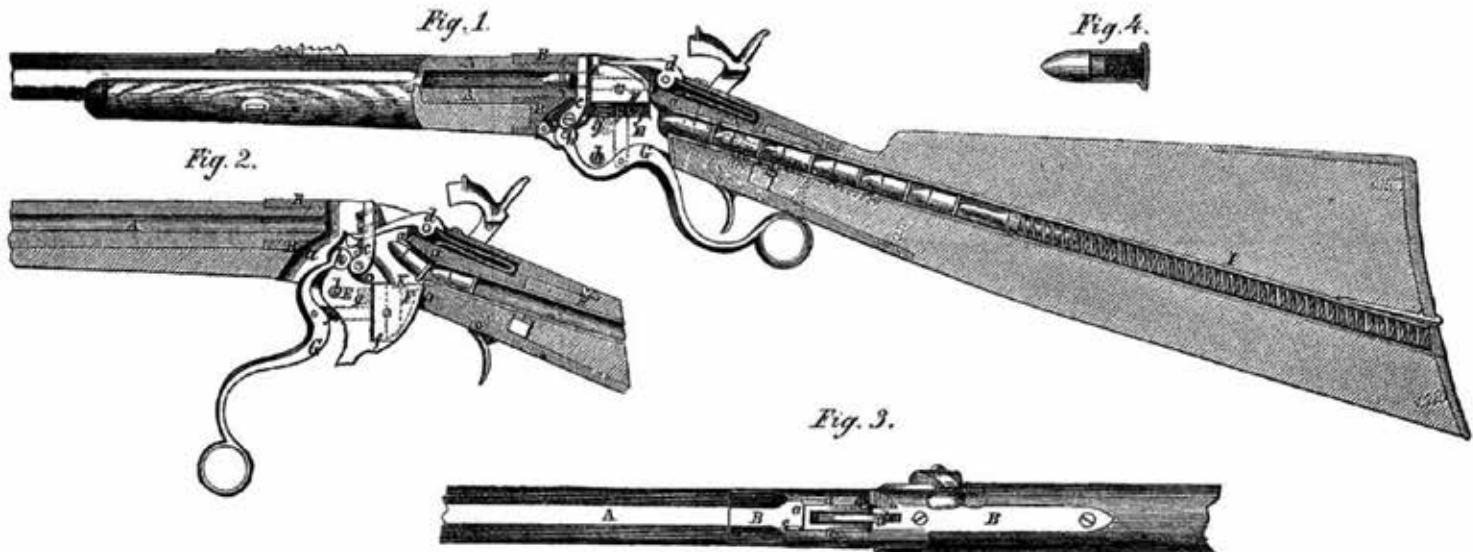


Figure 2: Spencer Rifle w/ forward feeding tubular magazine and rimfire ammunition.

on the reliable operation of the system feeding the weapon. Ammunition feeding system options include:

- Manual (cartridge or projectile pushed by human power)
- Tubular (forward and rear feed, involves a lifter to line the cartridge axis up with the chamber axis)
- Box magazine; internal and detachable (push feed / controlled feed)
- Rotary magazine (internal or detachable)
- Drum magazine (push feed, powered by coil spring)
- Links (rear strip, push strip, side strip, & delink)
- Linkless (carousel, rotary, linear, helical, with and without carriers)
- Rammer chain (large caliber)
- Flick rammers (large caliber)

Commonly used feed mechanisms and the gun operating cycles of significant weapons systems will be briefly discussed.

Early breech loading rifles, such as the Sharps, introduced in 1848, were manually fed. The Ruger #1 is quite similar and is shown in figure 1.

The patent application of the Spencer repeating rifle with its forward feeding tubular magazine is shown in figure 2. This patent incorporated pointed bullets (good from a reduced drag perspective), but the pointed bullets precluded use of centerfire primed ammunition and the long-range performance was thus limited

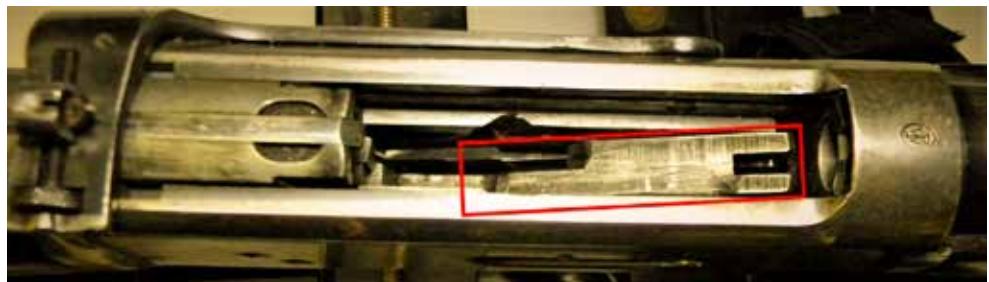


Figure 3: Winchester Model 94 with cartridge lifter identified.

by the comparably low peak pressures of rimfire cases.

The Winchester lever action rifle with its under-barrel tubular magazine was introduced in 1866; the rear feeding tubular magazine culminated with the Winchester Model 94 rifle in 1894. The nose-to-base stacking of cartridges in the tubular magazine

and the increased recoil of the first smokeless powder centerfire cartridge necessitated the use of flat nose bullets. The high drag and poor velocity retention of flat nosed bullets severely limited the usefulness of this cartridge for long-range applications. The Winchester Model 94 is shown in figure 3, with the lifter identified that aligns

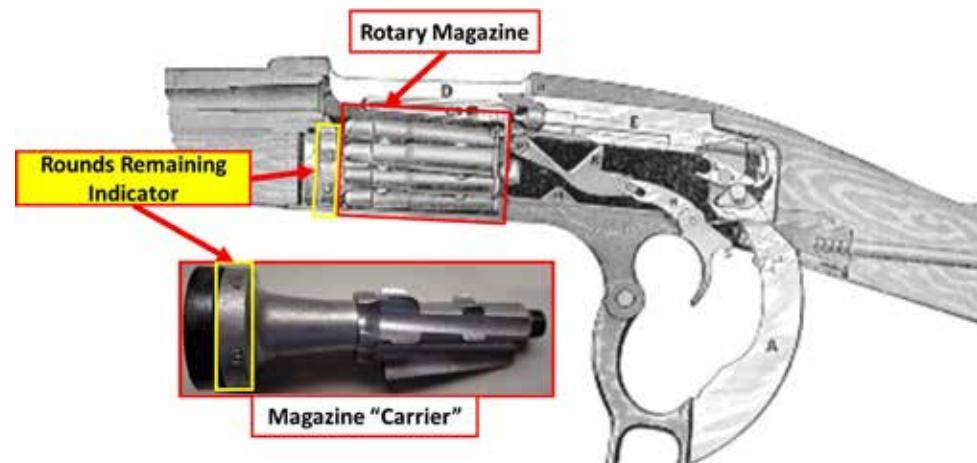


Figure 4: Savage 99 Rotary magazine and carrier.



Figure 5: Mauser 98, control feed start.

the cartridge with the chamber axis.

The Savage 99 has an internal rotary magazine that permits the use of pointed bullets in a lever action rifle. The rotary magazine stores the cartridges around the periphery of a steel

carrier in the receiver with the longitudinal axis of the cartridges oriented nearly parallel with the carrier axis. Operating the firearm lever pushes on the base of the cartridge, forcing it out of its location in the carrier and

chambering it. Low drag, pointed bullets could now be combined with high peak pressure centerfire cartridges to improve system long range performance. Figure 4 shows a cross-section of the Savage Model 99 with the lever



Figure 6: Mauser 98, control feed eject.

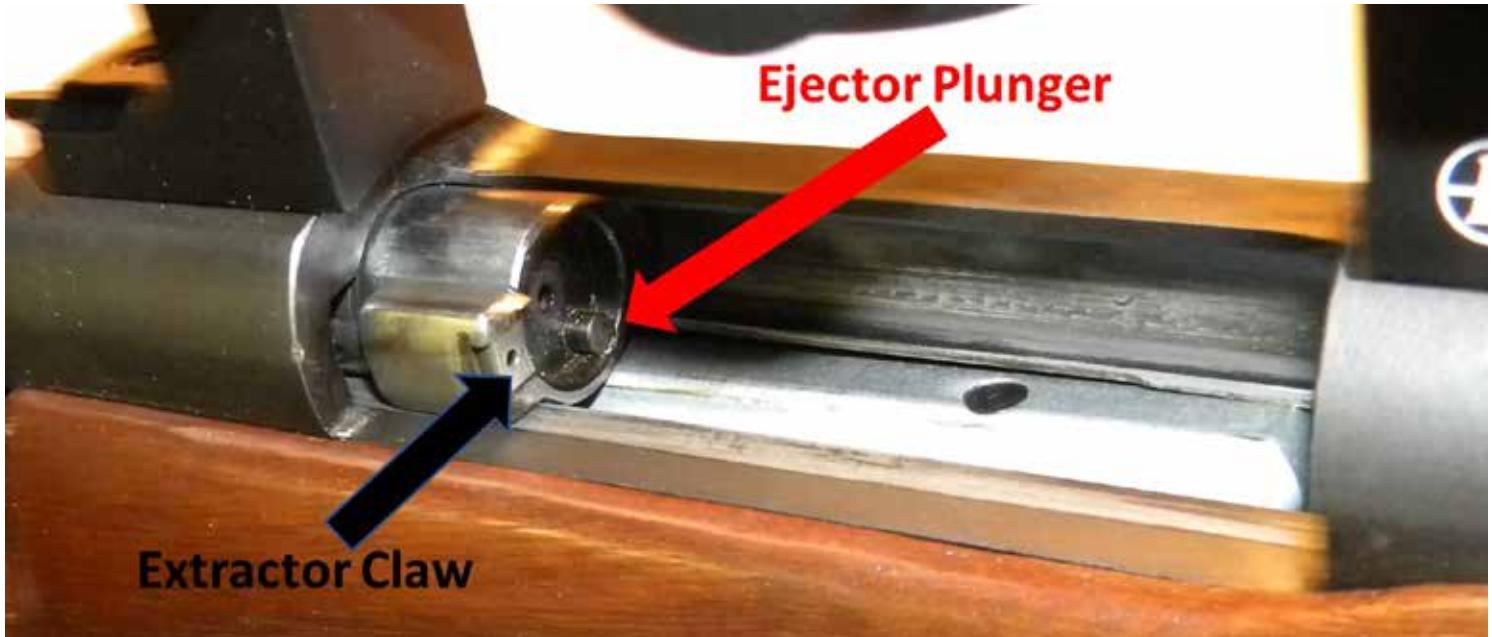


Figure 7: Winchester Model 70 push feed.



Figure 8: 9mm Luger single stack magazine.

open ready to feed a cartridge, while the inset shows the magazine carrier. The "rounds remaining indicator" wheel (spindle head) is also displayed for reference.

The Ruger 10/22 also uses a rotary magazine, but its magazine is detachable.

Bolt action rifles permitted higher peak chamber pressures than early lever action rifles and two basic design philosophies are used to feed them: controlled feed and push feed. These gun actions have been fed by clips as well as internal and detachable box magazines.

The Mauser 98 rifle is considered by many to be the pinnacle of controlled feed design as it retains positive positioning of the cartridge during



COURTESY SCOTT ZAMINER

Figure 9: 1895 Mannlicher (L) and 1938 Carcano single stack rifle clips.

all phases of the feed cycle. Figure 5 shows the Mauser 98 bolt and 8x57mm cartridge at the start of the feed cycle. The extractor groove of the cartridge will be captured by the extractor claw once a minor amount of bolt movement to the right is completed.

Figure 6 shows the Mauser 98 with the bolt positioned just prior to the base of the case contacting the eject pin.

Controlled feed reliability of the Mauser 98 depends on the forceful operation of the bolt fore and aft after unlocking and locking the bolt.

The other common bolt action feed mechanism is the so-called "push feed". The Winchester Model 70 uses a push feed design, shown in figure 7. Here, the face of the bolt pushes on the

base of the cartridge case in the magazine as the bolt is moved forward, the action of the magazine follower spring pops the cartridge vertically into alignment with the barrel chamber. Upon opening the bolt and moving it aft, the fired case is pulled from the chamber by the extractor claw and subsequently thrown clear of the feedway by the spring-loaded ejector plunger once the case mouth has been pulled aft of the receiver. Many other weapons (M4, M16, M240, AK-47, etc.) use push feed to strip cartridges off the feed mechanism and into the weapon chamber.

For pistols, single stack magazines were introduced for handguns such as the 7.65mm and 9mm Luger pistol



COURTESY SCOTT ZAMINER

Figure 10: M1 Garand double stack clip.

(1908), and John M. Browning's timeless 45ACP Model 1911 pistol. With single stack magazines, the cartridges are typically oriented vertically and the reciprocating motion of the bolt or slide strips a cartridge off the top of the magazine as the slide moves forward, and the remaining cartridges in the stack are pushed up by the com-

pressed spring below the magazine follower at the bottom of the stack. The reduced body taper of the cartridge case allows the magazine to be designed and manufactured with straight features. A Luger 9mm magazine is shown in Figure 8.

Single stack clips were used in early bolt action rifles; clips from a German

1895 Mannlicher and an Italian Carcano, Model 1938 are shown in Figure 9.

The US M1 Garand rifle used an "en-bloc" clip containing eight .30-06 cartridges, shown in figure 10. The entire clip was inserted into the top feed well of the M1 until the notch on the aft end of the clip latches it in place. An internal follower sequen-



Figure 11: 9mm Beretta Model 92 double stack magazine.



Figure 12: Fabrique Nationale 5.8x28mm P90 with magazine identified.

tially lifts cartridges into feed position after a cartridge is fired until the clip is empty. At this point, the bolt is locked back, the clip is ejected from the rifle, and a fresh clip is inserted.

The Beretta 92 is a handgun with a staggered double stack magazine, shown in figure 11. A cartridge in position to be picked up by the slide and fed into the chamber is shown on the left-hand side of Figure 11. Slightly to the right of the cartridge in the side of the magazine are indicated diamond-shaped indents that force the cartridges in the double stack to alternate toward the common feed point.

A variation on the double stack magazine is the unique P90 from Fabrique Nationale. Here, a double stack of nearly straight-walled cartridges is oriented with the axes of the cartridges perpendicular to the barrel axis. Figure 12 shows the P90 personal defense weapon with the magazine location.

As the P90 magazine follower pushes the cartridges aft, the double stack is narrowed to a single stack, and a specially designed cam path in the circular aft of the magazine rotates the cartridges 90 degrees in preparation for feeding into the chamber. A bottom view of the P90 magazine is shown in figure 13.

Carousel clips are found on Lewis machine guns; a cross-section of the carousel is shown in figure 14. The carousel rotates as the gun fires, indexing new cartridges into position to be ramped into the chamber by the motion of the bolt.

Drum magazines are found on the



Figure 13: Bottom view of the P90 magazine.

Thompson submachine gun, the 20mm Oerlikon M2 cannon (widely used during WWII), and the Russian PPSh-41. A partially loaded Thompson drum magazine is shown in figure 15. A coil spring provides the force to rotate the rounds in the magazine; the shooter must wind the coil spring prior to installation on the weapon. Here, the six "webs", powered by a coil spring, rotate the cartridges (clockwise) along an outward spiral track, pushing them toward the feed position shown at the top of the drums.

Open ended, double stack, helical magazines are found on Calico weapons. The 9mm carbine/pistol uses a roller delayed blow-back operating mechanism. The spiral storage arrangement of the ammunition provides a magazine with much smaller frontal area than a comparable capacity drum magazine, at the expense of increased length. Internal partitions control the longitudinal position of the cartridges in the magazine, while the drive helix and a follower advance the cartridges toward the feed position.

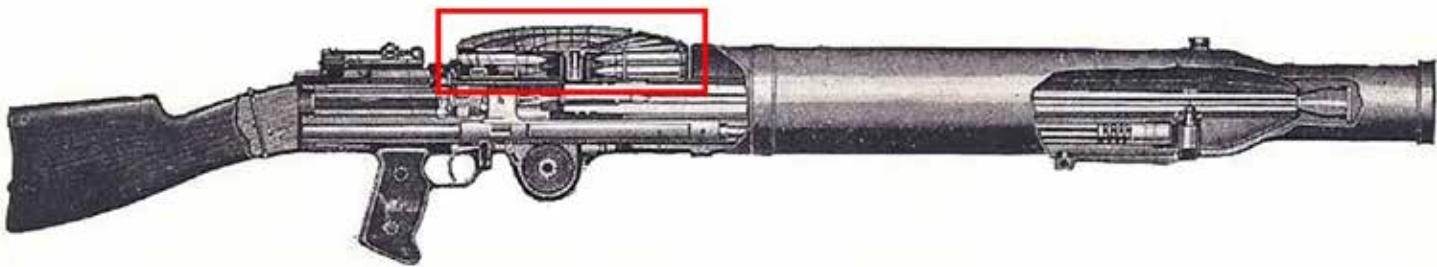


Figure 14: Carousel magazine on Lewis machine gun.

An internal coil spring rotates the drive helix, rotating the stored ammunition rearward in a spiral loop through the magazine, toward the feed point. The Calico magazine is shown in figure 16.

Links are used for guns requiring expanded ammunition capacity, they come in three basic variations; forward (or push) stripping, rear stripping, and side stripping. The M249 in 5.56x45mm and the M240 in 7.62x51mm both use forward stripping links in these gas-powered guns. An M13 push stripping link used in the M240B is shown in figure 17.

The rear stripping M9 link used on the short recoil operated M2 .50 caliber machine gun is shown in figure 18. Here, the link is restrained at the aft by the feeder, and the cartridge is pulled aft out of the link by the cartridge extractor attached to the bolt as the bolt travels aft after firing and is ejected. A fresh cartridge is then lowered in line with the barrel chamber, and fed into the weapon as the bolt returns to battery.

An unusual variation on the aft stripping link is found on the M16A2 link used on the ammunition for the Mk19 high velocity 40mm grenade launcher. This cartridge uses a "hi-low" propulsion system which burns flake propellant in the high-pressure side of the cartridge at the aft end of the case, and then vents those gasses to the low-pressure side of the case behind the projectile to push it down the barrel. This propulsion system provides more complete combustion of the propellant, enhancing weapon reliability. The thick walls at the aft end of the M169 case allow the aft end of the case to not need to be fully inserted into the chamber to survive firing. This allows the link to simply slide aft from its initial position on the projectile rotating band, along the case body as the cartridge is chambered, eliminating the need to strip the link. Since the Mk19 is a blow-back operated gun using advanced primer ignition, the



Figure 15:  
Thompson  
drum magazine.

energy that would have been required to strip the link from the cartridge would have had a detrimental effect on reliable function. Instead, the Mk19 pulls the cartridges aft during the recoil cycle, breaking the U-shaped link connection shown at the top of figure 19.

Side strip links are used on many medium caliber guns such as the 20mm M61, the 25mm M242, and the 30mm Mk44. Figure 20 shows a side stripping 20mm link with a "tee" slot which is

used to pull the link laterally off the cartridge as the declutching feeder pulls the link belt from the ammunition storage and feeds ammunition into the rotary cannon. To prevent cook-offs, in some M61 applications, the feeder declutches (stops feeding ammunition) to allow the barrel cluster to continue to rotate to clear the gun, preventing live rounds from remaining in contact with a hot barrel.

Rotary linkless feed systems were

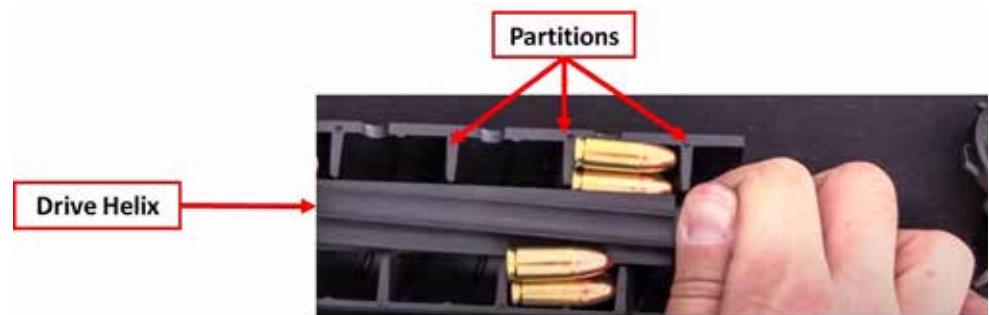


Figure 16: Calico double stack helical feed magazine.

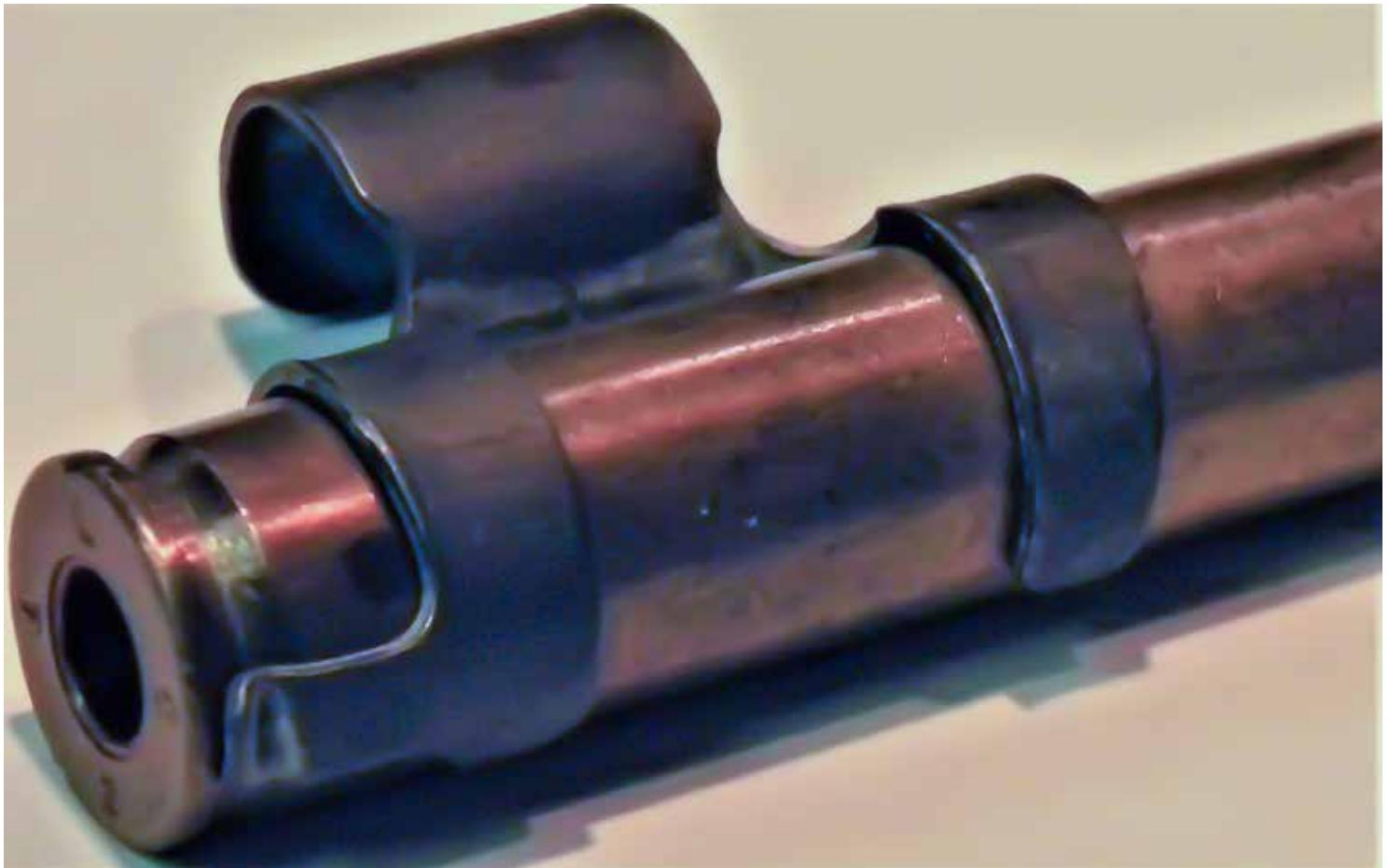


Figure 17: Forward link example: M13 link for 7.62x51mm.

developed in the 1970's by General Electric for the externally powered, six-barreled M61 Gatling gun in response to an Air Force requirement for a gun feed system more reliable under platform "G" loading than existing link systems. High lateral accelerations in dogfight conditions caused large link-link contact loads which lead to link separations when firing the gun. Feeding of Gatling guns is more complicated than single barrel weapons because, due to structural reasons, the spacing between barrels in the gun is larger than the weight/volume efficient spacing between the cartridges in the feed system. This requires the rounds coming from the feed system to be laterally accelerated as rounds are fed into the gun.

Figure 21 shows the internal working of the rotary linkless feed system. Instead of all the cartridges rotating in the carousel like in the Lewis gun, cartridges in rotary linkless feed systems are pushed along rails called "partitions". Partitions are fastened to the inside surface of the feed drum, and cartridges are moved along the partitions by a helical screw. At the exit end of the drum is a "scoop



Figure 18: M9 Link for M2 Machine Gun.



Figure 19: High velocity 40mm CTG M16A2 link with fired M169 cartridge case.



Figure 20: Side strip M14A2 20mm links.

disk" that rotates with the feed helix and sequentially pulls cartridges off the partitions and puts the cartridges into conveyor elements running at gun rate to be fed into the gun. Conveyor elements take cartridges to the gun feeder where they are accelerated to "gun pitch", laterally fed into the gun, and fired. For fixed wing aircraft, the fired cartridges are removed from the gun, put back into conveyor elements, and returned to the back end of the feed drum to prevent the aircraft from flying through a shower of fired cases.

Despite their high reliability and low power consumption, rotary feed systems are obsolete in fighter aircraft because linear linkless feed systems have less "dead space" around them. This volume can be used for other important things like avionics.

Linear linkless systems run at "gun rate", which requires copious amounts of power to accelerate all the ammunition to firing rates generally north of 3000 shots per minute. Figure 22 shows the linear linkless feed system used on the F15E.

Linear linkless feed systems come in two basic varieties, chain ladder and helical. In chain ladder systems, ammunition is closely packed, with cartridges adjacent to one another and in close to the same plane as the gun feeder. This minimizes loads on the feed elements, improving reliability and parts life. The

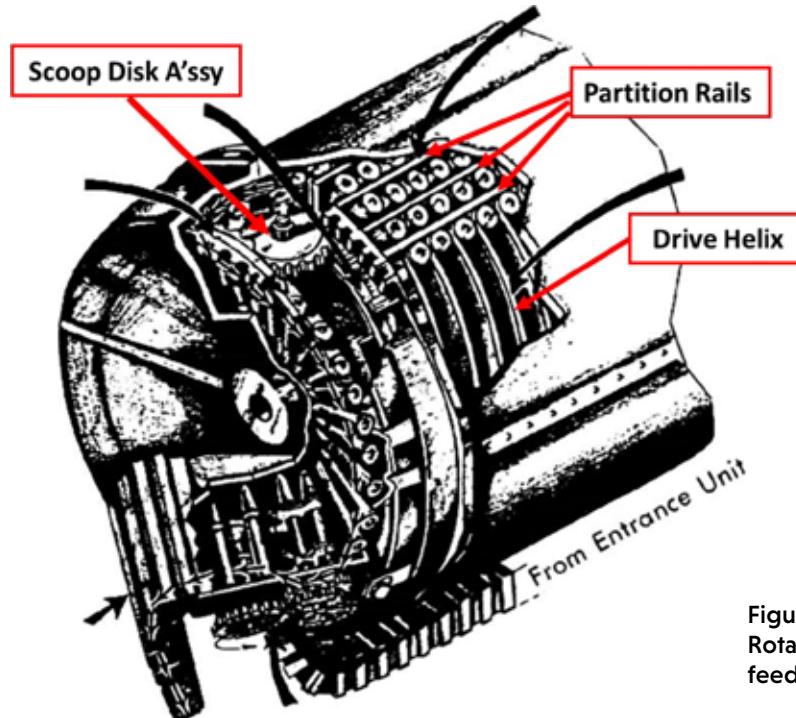


Figure 21:  
Rotary linkless  
feed system.

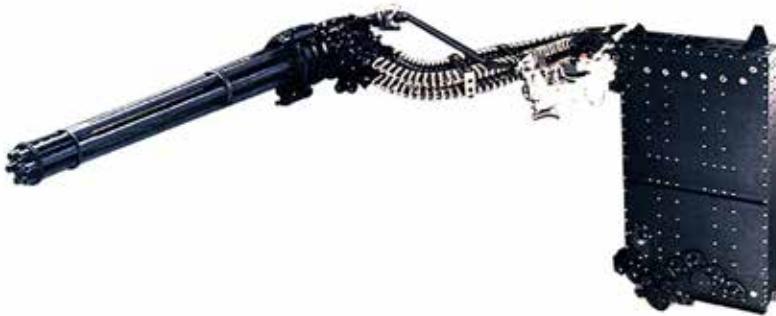


Figure 22:  
F15E linear  
linkless feed  
system and  
M61A1 gun.

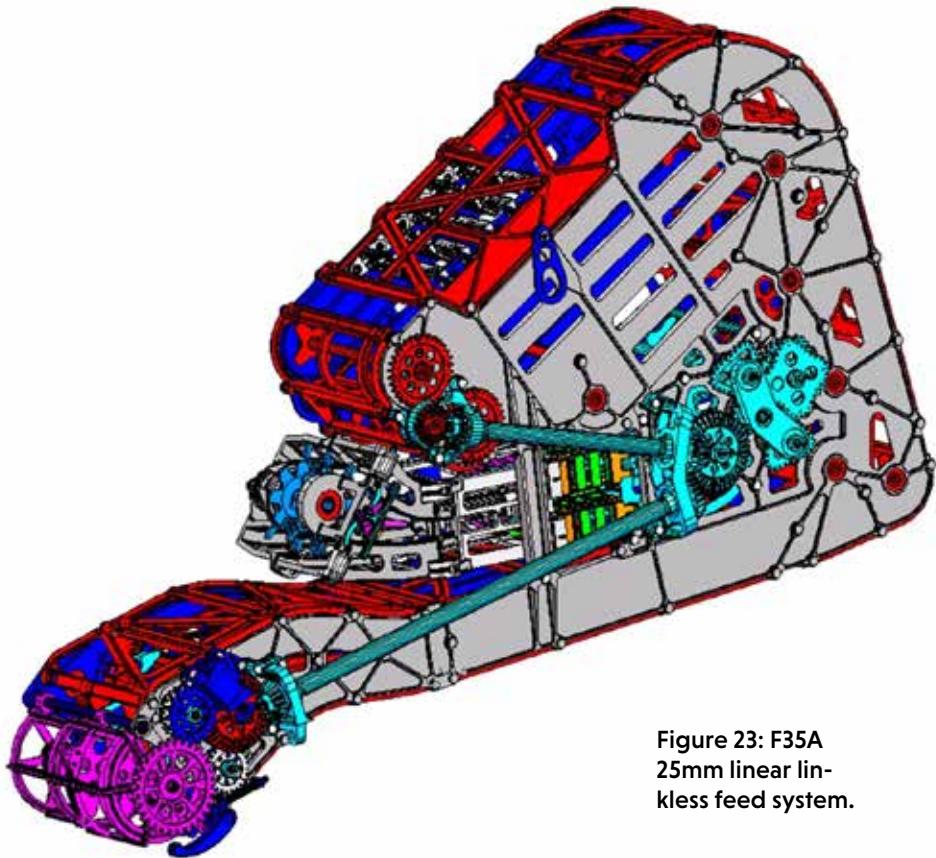


Figure 23: F35A  
25mm linear linkless feed system.



Figure 24: GPU-5/A carrier elements and helical feed system.

Figure 25: GPU-5/A fourth order elliptical feeder gears.



F35A gun system is shown in figure 23. In these systems, rounds are moved at gun rate in a "chain ladder" in the ammunition storage unit until entering the feeder.

Helical linkless feed systems were first developed in medium caliber in the late 1970's to early 1980's time frame by General Electric for the GPU-5/A 30mm gun pod. This system is shown in figure 24. This system employed carrier elements to securely control round position. Carrier elements are wrapped around the gun in a spiral fashion with inner and outer loops, intermediate feed system drives prevent the carriers from bunching up as they traverse the feed system. The four-barreled GAU-13/A gun system had barrel pitch intervals very much larger than the carrier spacing, necessitating significant round acceleration prior to feeding into the gun. Conventional feeders developed with circular gears required many sprockets and round "hand-offs", resulting in a heavy and power-hungry system. Weight reduction efforts lead to the design of a much lighter feeder with only two hand-offs, made possible through the use of fourth order elliptical gears, shown in figure 25. More than 25 years later, the helical feed system design would be reprised in the F35-B gun system.

## Conclusions

Feed systems have evolved to meet the needs of the weapon for which they are used, based on the expectations and requirements of the customer. They run the gamut from slow and simple, with meagre capacity, to fast and sophisticated with many cartridges. Ultimately, the user determines the number of rounds needed, then it's left to the designer to decide what package meshes best with the gun mechanism and the platform weight, power and volume restrictions. SADJ

## RESOURCES

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- [wikipedia.org](https://en.wikipedia.org)
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- [gunpartscorp.com](http://gunpartscorp.com)
- [youtube.com GPU 5A by Clyde Dale](https://www.youtube.com/watch?v=KXWzvIjyfYU)
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## Elbit Systems U.S. Subsidiary Awarded \$54 Million Enhanced Night Vision Goggle Order for the U.S. Army

**Elbit Systems** announced that its U.S. subsidiary, Elbit Systems of America, was awarded a second production order in the amount of approximately \$54 million to supply Enhanced Night Vision Goggle – Binocular “ENVG-B” systems, provide spare parts, logistics support and test

equipment for the U.S. Army. The order will be executed in Roanoke, Virginia and will be supplied through February 2023. This order is part of an Other Transaction Authority (“OTA”) contract that could reach a maximum amount of approximately \$442 million.

# Smith & Wesson to Relocate Headquarters to Tennessee

**Smith & Wesson Brands, Inc.** announced that it's moving its headquarters and significant elements of its operations to Maryville, Tennessee in 2023. Smith & Wesson has been based in Springfield, Massachusetts since the company was incorporated in 1852.

Mark Smith, President and Chief Executive Officer, said "This has been an extremely difficult and emotional decision for us, but after an exhaustive and thorough analysis, for the continued health and strength of our iconic company, we feel that we have been left with no other alternative." He specifically cited legislation recently proposed in Massachusetts that, if enacted, would prohibit the company from manufacturing certain firearms in the state. "These bills would prevent Smith & Wesson from manufacturing firearms that are legal in almost every state in America and that are safely used by tens of millions of law-abiding citizens every day exercising their Constitutional 2nd Amendment rights, protecting themselves and their families, and enjoying the shooting sports. While we are hopeful that this arbitrary and damaging legislation will be defeated in this session, these products made up over 60% of our revenue last year, and the unfortunate likelihood that such restrictions would be raised again led to a review of the best path forward for Smith & Wesson."

Smith indicated that the company vetted a number of cities and states and, after careful consideration, made the decision to relocate 750 jobs and its headquarters to Maryville, Tennessee. S&W said key factors in the decision included support for the 2nd Amendment, a business friendly environment, quality of life for employees, availability of qualified labor for its operations and headquarter functions, among others.

Smith & Wesson will also close facilities in Connecticut and Missouri as part



of consolidating in Tennessee. This process will result in the company reducing the number of locations it maintains from four to three and will significantly streamline its manufacturing and distribution operations. The company emphasized that the move will not begin until 2023 and will not have an impact on employees' jobs until then.

Smith & Wesson shared these key facts:

- The facility in Springfield, Massachusetts will be reconfigured but will remain operational.
  - Smith & Wesson will keep some of its manufacturing operations in Springfield, Massachusetts, including all forging, machining, metal finishing, and assembly of revolvers, and will continue to have over 1,000 employees in the state.
  - The new facility will be built in Maryville, Tennessee and will comprise of the company's headquarters, plastic injection molding, pistol and long gun assembly, and distribution.
  - Total investment in the project is estimated at \$120 million, will be funded from cash on hand.
- Construction in Maryville, Tennessee is expected to begin in the calendar fourth quarter of 2021 and be substantially complete by the summer of 2023.
  - Upwards of 750 jobs will move from Springfield, Massachusetts; Deep River, Connecticut; and Columbia, Missouri to Maryville, Tennessee.
  - The company's plastic injection molding facility in Deep River, Connecticut, which services both Smith & Wesson as well as a significant number of external customers, will be sold. The Smith & Wesson portion of the operations will be moved to the new facility in Maryville, Tennessee, however, the external customer business will remain in Connecticut and will be divested.
  - The company's distribution operations in Columbia, Missouri will be moved to the new facility in Maryville, Tennessee, and the Columbia, Missouri facility will be marketed for sublease.
  - The relocation will have no impact on the company's operations in Houlton, Maine.

# KWESST Announces New System to Counter Loitering Munition Drones

**KWESST Micro Systems Inc.** announced the development of a new system to counter the rapidly emerging threat of "Loitering Munitions."

Unlike conventional drone threats programmed or guided to fly straight to a target area for surveillance or to attack with improvised explosives, a Loitering Munition (LM) is an autonomous, military grade suicide drone with a built-in warhead that can hover in an area for extended periods to search for targets, then attack selectively once a desired target is located.

"The threat of Loitering Munitions has been described as nothing less than a revolution in land warfare," said Jeff MacLeod, Founder, President and CEO of KWESST. The recent conflict in Nagorno-Karabakh is a widely cited contemporary example



of how Loitering Munitions can play a decisive role in outcomes, leaving ground forces exposed and vulnerable. More than a dozen countries currently have loitering munitions, and many more are in the process of adopting them as an economic replacement for missile systems, with surgical precision and highly destructive effects.

Details of KWESST's CLM solution are sensitive for security and competitive reasons. In concept,

it receives a signal from any third-party drone detection system to locate the loitering munition, then launches an unmanned platform with a proprietary payload into its pathway to neutralize it. The nature of the neutralization method allows the system to also be safely used against domestic drone threats at sensitive facilities and public events without risk of collateral damage.

KWESST has partnered with a leading U.S. drone engineering company, to carry KWESST's neutralizing payload. Together, the two companies have successfully completed the feasibility phase and have begun work to produce functioning demonstration units by early 2022, with plans for trials with U.S. military agencies in the second calendar quarter of 2022.

## CZ Group Completes Acquisition of Colt

After securing all necessary regulatory approvals from U.S. and Canadian authorities, CZ Group has successfully completed its acquisition of Colt, the parent company of U.S. firearms manufacturer, Colt's Manufacturing Company LLC, as well as its Canadian subsidiary, Colt Canada Corporation.

"Colt is pleased to join forces with CZG," said Dennis Veilleux, President and CEO of Colt. "We are proud of our heritage and believe that the strength of the combined businesses and the many synergies created by the merger will enable us to honor our roots while also securing the future of the Colt brand."

According to a Colt press release, CZG

and Colt are confident the merger will bring significant operational, commercial, and R&D synergies for the combined business, which together generated estimated sales in excess of U.S. \$570 million in 2020 with more than 2,000 employees in the Czech Republic, the United States, Canada and Germany.

"With this acquisition, we have created a strategic relationship between CZG and Colt which will bring significant opportunities for the group," says Lubomír Kovařík, Chairman and President of CZG. "This merger also confirms our commitment to the North American market, which is an integral part of our growth strategy."



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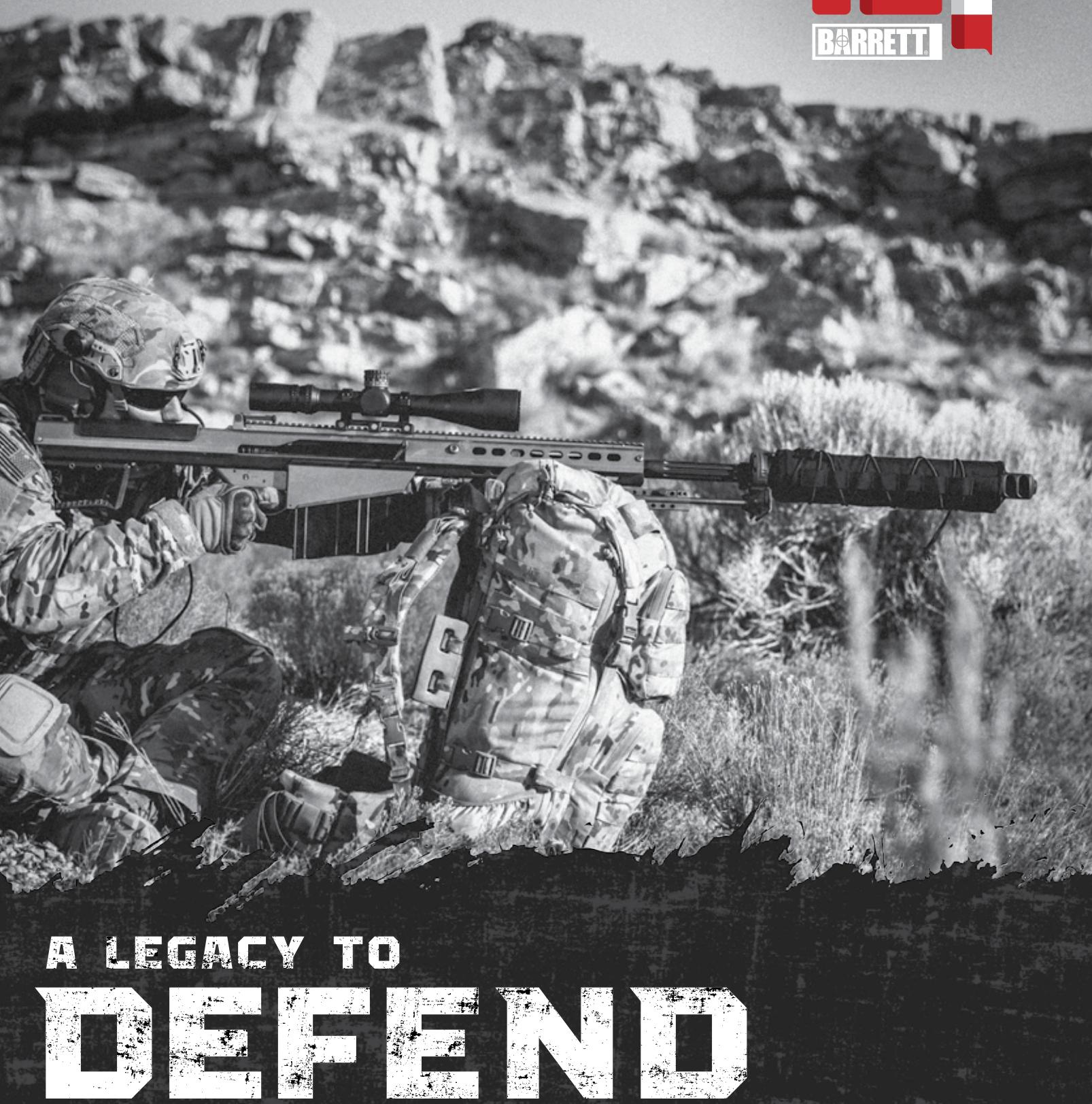
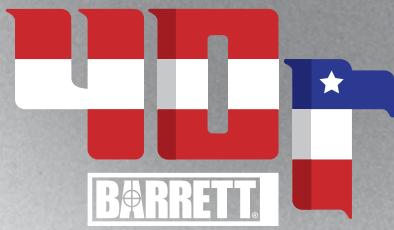
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